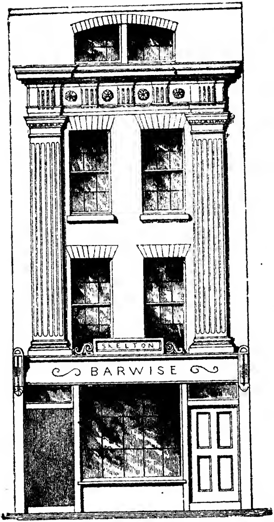

ORNAMENTAL BRICKWORK.

No. 43, St. Martin's Lane, London.

A RUDIMENTARY TREATISE

ON THE MANUFACTURE OF

BRICKS AND TILES

CONTAINING AN OUTLINE OF THE

PRINCIPLES OF BRICKMAKING

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"FOUNDATIONS AND CONCRETE WORK," ETC., ETC.

TENTH EDITION.

WITH ADDITIONS AND THE PRICES CORRECTED TO DATE

With Numerous Illustrations

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THE AUTHOR'S PREFACE.

THE preparation of this little work has necessarily extended over a considerable period of time, and, although our limits preclude anything like an attempt at a complete view of the principles and practice of Brickmaking, it will be found to contain much practical information which has never yet been published, and descriptions of processes which are little known beyond the localities where they are practised. The whole of the illustrations have been drawn expressly for the work, and the descriptions of tools and processes have been written from personal observation, no dependence having been placed on verbal description, even by experienced workmen. Working brickmakers are mostly illiterate men, unable to describe correctly their own operations, and still less to explain their meaning. I have therefore considered it necessary to have every process here described carefully watched throughout, either by myself or by some one on whose accuracy of observation I could place dependence.

In the course of last autumn I drew up several papers of questions, embracing a variety of points on which it was found difficult to obtain correct information, but which were distributed amongst those of my friends who were likely to have opportunities of ascertaining what was required.

Many of these papers in course of time were returned, accompanied by valuable details, and I have to express my thanks and obligations to many gentlemen personally unknown to me for the assistance thus afforded. Amongst those from whom I have received valuable assistance during the progress of the work, I may especially mention the names of Mr. Arthur Aikin; Mr. John Lees Brown, of Lichfield; Mr. William Booker, of Nottingham; Mr. Richard Prosser, of Birmingham; and Mr. Frederick Ransome, of Ipswich.

Mr. Richard Prosser has kindly contributed a valuable account of the practice of Brickmaking in Staffordshire, which will be read with much interest, and it will be worth the reader's while to compare the processes described in this chapter with those made use of in the neighbourhood of Nottingham, described in Chapter III.

The details given in Appendix I. respecting the manufacture of Suffolk bricks were kindly furnished by Mr. Frederick Ransome, to whom I am also indebted for drawings of a Suffolk kiln, which were intended by him as a contribution to the work, but which, unfortunately, were committed to the post for transmission, and never reached their destination.

In collecting the information requisite for writing the accounts of Brickmaking and Tilemaking as practised in the neighbourhood of London, I am under great obligations to Mr. Adams and Mr. Randell, of the Maiden Lane Tileries, and to Mr. Samuel Pocock, of the Caledonian Fields, Islington, for the kindness with which they afforded me facilities for inspecting and sketching their works, and for the liberal manner in which they furnished me with details of prices and quantities.

Although much time and pains have been bestowed upon the work, there is so much difficulty in writing a strictly accurate account, even of a simple operation, that I cannot hope that it is perfectly free from errors; but I trust that they are only of a trivial nature, and I shall be greatly obliged to any reader who will point out any omissions or mis-statements, that I may be able to correct them in a future edition.

There has long been a want of rudimentary treatises on the Materials of Construction, published in a cheap form, and written in a simple and practical style, divested of scientific technicalities, which render such books nearly useless to those by whom they are most needed. I venture to express a hope that this work may be of service in supplying this deficiency with regard to one very important class of building materials. At the same time it must be observed that the *Science* of Brickmaking is as yet untrodden ground, comparatively little being known of the manner in which different substances mutually act upon each other when exposed to furnace heat, or of the relative proportions of silica, alumina, lime, and other usual ingredients of brick-earths, which are best calculated to produce a sound, well-shaped brick, of a pleasing colour. All that I have attempted here, therefore, is to give a clear description of the actual manufacture of bricks and tiles, and to explain the leading differences which exist in the manner of conducting the several operations of Brickmaking in various parts of this country. How far I have succeeded in this attempt the reader alone can determine.

PREFACE TO THE FOURTH EDITION.

This work was revised by Professor Tomlinson in 1863, and some matter become useless by time and the alteration of the Excise laws judiciously expunged. A chapter was at the same time appended on making bricks by machinery, but since that period many improvements and new inventions have necessitated a supplemental chapter, in which the editor has endeavoured to give an outline of that part of the subject reaching to the present day. He has also added a sketch of that which was properly called by the author of the work the *Science* of Brickmaking. A few notes, revising the text generally, will be found in the Appendix, and to which the alphabetical index now given affords easy reference.

Though small and elementary, this work may probably claim to be the most complete upon its subject in the English language.

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RUDIMENTS

OF THE

ART OF MAKING BRICKS AND TILES.

INTRODUCTION.

I. It would be impossible, in a little volume like the present, to enter at any length upon the early history of the Art of Brickmaking, nor would such an investigation, however interesting in a historical point of view, add much to our practical knowledge of the subject. It is, however, desirable that we should give a few particulars relative to the progress of the manufacture in this country; and we propose at the same time to give a brief sketch of the legal restrictions which have been imposed from time to time upon the mode of conducting the operations of the brickmaker.

II. The use of brick as a building material, both burnt and unburnt, dates from a very early period. Burnt brick is recorded in the Bible to have been used in the erection of the tower of Babel; and we have the testimony of Herodotus for the fact, which is confirmed by the investigations of travellers, that burnt bricks, made from the clay thrown out of the trench surrounding the city, were used in building the walls of the city of Babylon. These very ancient bricks were of three kinds; one of which was very similar to the modern white Suffolk bricks, and another to the ordinary red brick of the present day.

Sun-dried bricks were extensively used in ancient times, especially in Egypt, where their manufacture was considered a degrading employment, and, as such, formed the principal occupation of the Israelites during their bondage in Egypt after the death of Joseph. Very interesting ancient representations of the processes employed are still in existence, and throw much light on various passages of Scripture. Thus, the passage in Psalm lxxxi. 6, "I removed his shoulder from the burden; his hands were delivered from the (*water*) pots," is strikingly illustrated by pictures still preserved to us, in which labourers are carrying the tempered clay on their shoulders to the moulders, whilst others are engaged in carrying vessels of water to temper the clay. The Egyptian sun-dried bricks were made with clay mixed with chopped straw, which was furnished to the Israelites by their Egyptian taskmasters before the application of Moses to Pharaoh on their behalf, after which the obligation was laid on them to provide their own straw, which appears to have been a grievous addition to their labour. It would appear from the details given, that the Israelites worked in gangs, under the superintendence of an overseer of their own nation, who was provided with all necessary tools and materials, and who was personally responsible for the labour of the gangs.

Burnt bricks were, however, also used in Egypt for river walls and hydraulic works, but, probably, not to any very great extent.

It is recorded in 2 Samuel xii. 31, that David put the children of Ammon under saws, and harrows, and axes of iron, and made them pass through the brick-kiln: without entering on the question whether the Ammonites were made to labour in the brickfields as the Israelites had themselves previously done during the time of their bondage in Egypt, or whether we are to understand that they were put to death with horrible tortures, as supposed by most commentators, there is a strong presumption that the implements here spoken of in connection with the brick-kiln were employed in the preparation of the clay; and if this view be correct, the passage is interesting as evidence of the use of machinery in making bricks at a very early period of history.

III. The Romans used bricks, both burnt and unburnt, in great profusion; all the great existing ruins at Rome being of brick. At the decline of the Roman Empire, the art of brickmaking fell into disuse, but was revived in Italy after the lapse of a few centuries. The mediæval ecclesiastical and palatial architecture of Italy exhibits many fine specimens of brickwork and ornamental work in terra-cotta; cornices and other decorations of great beauty being executed in the latter material.

IV. In Holland and the Netherlands, the scarcity of stone led, at an early period, to the extensive use of brick, not only for domestic but for ecclesiastical buildings, and these countries abound in fine specimens of brickwork, often in two colours, combined with great taste, and producing a very rich effect, as in the celebrated examples at Leeuwarden in Friesland. It is worthy of remark, that in the fens of Lincolnshire and Norfolk, where we should naturally have expected to have found the same material made use of, the churches, many of which are exceedingly fine specimens of architecture, are built of small stones, said to have been brought from a great distance on pack-horses.

V. Brickmaking appears to have been introduced into England by the Romans, who used large thin bricks or wall tiles as bond to their rubble constructions; and such wall tiles continued to be used in England until rubble work was superseded by regular masonry, about the time of the Norman Conquest. Brick does not appear to have come into general use as a building material until long afterwards.

In the reign of Henry VIII., however, the art of brickmaking had arrived at great perfection, and the remains of many buildings erected about this time exhibit some of the finest known specimens of ornamental brickwork.

The following is a list of some of the principal brick buildings erected at the period of which we speak :—

NAME.	WHEN BUILT.
Hurstmonceaux Castle, Sussex .	Early in the reign of Henry VI.
Gate of the Ryehouse in Hertfordshire	Ditto.
Tattershall Castle, Lincolnshire . .	A.D. 1440.
Lollards' Tower, Lambeth Palace .	A.D. 1454.
Oxborough Hall, Norfolk . . .	About A.D. 1482.
Gateway, Rectory, Hadleigh, Suffolk .	Close of 15th century.
Old part of Hampton Court . .	A.D. 1514.
Hengrave Hall, Suffolk . . .	Finished A.D. 1538.
Manor House, at East Barsham, Norfolk	During the reign of Henry VII.
Thorpland Hall, Norfolk . . .	Ditto.
Parsonage House, Great Snoring, Norfolk	During the reign of Henry VIII.

Many of these buildings have been engraved in Pugin's "Examples of Gothic Architecture," to which we would refer the reader. The decorative details of the Manor House at East Barsham, and of the Parsonage House at Great Snoring, are particularly worthy of notice;

the panelled friezes, cornices, and other ornamental work, being constructed of terra-cotta moulded to the required form. The use of terra-cotta for decorative panels and bas-reliefs appears to have been common during the reign of Henry VIII. The gateway of York Place, Whitehall, designed by Holbein, was decorated with four circular panels, which are still preserved at Hatfield Peveril, Hants.

The gateway of the Rectory in Hadleigh churchyard is very similar in character to that at Oxborough Hall, engraved in Pugin's work, above referred to. It has been lately restored very carefully, the terra-cotta work for the purpose being made at the Layham Kilns, near Hadleigh, in moulds of somewhat complicated construction.

In the time of Queen Elizabeth, brick seems only to have been used in large mansions. For common buildings, timber framework, filled in with lath and plaster, was generally used, and this construction was much employed, even when brickwork was in common use, the brickwork, up to a late period, being merely introduced in panels between the wooden framing.

VI. On the rebuilding of London after the great fire of 1666, brick was the material universally adopted for the new erections, and the 19th Car. II. c. 11, regulated the number of bricks in the thickness of the walls of the several rates of dwelling-houses. One of the resolutions of the corporation of the city of London, passed about this time, is interesting; it is as follows:—"And that they (the surveyors) do encourage and give directions to all builders, for ornament sake, that the ornaments and projections of the front buildings be of rubbed bricks; and that all the naked parts of the walls may be done of rough bricks, neatly wrought, or all rubbed, at the direction of the builder, or that the builders may otherwise enrich their fronts as they please."

Much of the old brickwork still remaining in London, in buildings erected at the end of the 17th and beginning of the 18th century, is very admirably executed. The most remarkable feature of the brickwork of this period is the introduction of ornaments carved with the chisel. A fine example of this kind of work is shown in the Frontispiece,* which is a sketch of No. 43, St. Martin's Lane, one of a block of houses built by a person of the name of May, who about the same time erected May's Buildings, to which the date of 1739 is affixed. The house in question is said to have been intended by Mr. May for his own residence. Its decorations consist of two fluted Doric pilasters, supporting an entablature, the whole executed in fine red brickwork; the mouldings, flutings, and ornaments of the metopes having been carved with the chisel after the erection of the walls.†

VII. It was not till the close of the last century that bricks were subjected to taxation. The 24th Geo. III. c. 24, imposed a duty of 2*s*. 6*d*. per thousand on bricks of all kinds. By the 34th Geo. III. c. 15, the duty was raised to 4*s*. per thousand. By the 43rd Geo. III. c. 69, bricks were divided into common and dressed bricks, and separate rates of duty were imposed on each kind. These duties and those on tiles were as follows:—

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* The author is indebted to the kindness of Mr. Edis for this sketch of one of the most interesting specimens of ornamental brickwork in the metropolis.

† This fact was discovered some years ago, when the house was undergoing a thorough repair, and the scaffolding afforded facilities for a close inspection of the ornamentation. Cast terra-cotta imitations of carved stone for architectural decoration were sent by Mr. Blanchard to the Exhibition of 1851, and were strongly recommended in the Jury Report, Class XXVIII.

SCHEDULE (A)—DUTIES.

[*Repealed* 1850.]

BRICKS AND TILES.

	£	s.	d.
For every thousand bricks which shall be made in Great Britain, not exceeding any of the following dimensions, that is to say, ten inches long, three inches thick and five inches wide	0	5	0
For every thousand of bricks which shall be made in Great Britain exceeding any of the foregoing dimensions	0	10	0
For every thousand of bricks which shall be made in Great Britain, and which shall be smoothed or polished on one or more side or sides, the same not exceeding the superficial dimensions of ten inches long by five inches wide	0	12	0
For every hundred of such last-mentioned bricks, exceeding the aforesaid superficial dimensions	The duties on paving-tiles.		
For every thousand of plain tiles which shall be made in Great Britain	0	4	10
For every thousand of pan or ridge tiles which shall be made in Great Britain	0	12	10
For every hundred of paving tiles which shall be made in Great Britain not exceeding ten inches square	0	2	5
For every hundred of paving tiles which shall be made in Great Britain exceeding ten inches square	0	4	10
For every thousand tiles which shall be made in Great Britain, other than such as are hereinbefore enumerated or described, by whatever name or names such tiles are or may be called or known	0	4	10

N.B.—The said duties on bricks and tiles to be paid by the maker or makers thereof respectively.

By the 3rd William IV. c. 11 (1833), the duties on tiles* were wholly repealed, and two years afterwards the duty on bricks was again raised, making the duty on common bricks 5*s*. 10*d*. per thousand.

The brick duties formed the subject of the 18th Report of the Commissioners of Excise Enquiry, 1836; and in 1839 these duties were repealed by the 2nd and 3rd Vict. c. 24, and a uniform duty of 5*s*. 10*d*. per thousand imposed on all bricks of which the cubic content did not exceed 150 cubic inches, without any distinction as to shape or quality.

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* By a curious oversight, this Act, which was intended to put *roofing tiles* on the same footing as slates, also repealed the duties on *paving* tiles, whilst *bricks* used for paving remained subject to duty as before. Thus a lump of clay put into a mould of 10 in. × 5 in. × 3 paid duty, but the same quantity of clay put into a mould 10 in. square was duty free, because it came under the denomination of a tile. The manufacturer, and not the public, reaped the advantage thus given.

VIII. The new Act was a great boon to the public as well as to the trade, as, in consequence of the removal of the restrictions on shape, bricks might be made to any required pattern; and moulded bricks for cornices, plinths, string-courses, &c., could be manufactured at a moderate price. Under the old regulations, also, the brickmaker was precluded from correcting any defect which might arise from warping or twisting in the process of drying, without making himself liable to pay the higher rate of duty. In 1850 the duty on bricks was entirely repealed.

IX. The number of bricks annually made in Great Britain is very great; just before the duty was repealed, a charge was made on about 1,800,000,000 bricks annually. In 1854 the number manufactured was estimated to be over 2,000,000,000, of which about 130,000,000 were made in the brickfields in and around Manchester, and about a similar number by the London brickmakers. The weight of this annual produce is upwards of 5,400,000 tons, representing a capital employed probably exceeding £2,000,000. Comparatively few bricks are made in Scotland, on account of the abundance of stone in that country. Those who are not practically connected with engineering works may find some difficulty in forming a clear conception of the immense number of bricks annually made for railway purposes; and which may be roughly estimated at from 600 to 800 millions annually. In 1821, before the introduction of the railway system, the number of bricks charged with duty in England and Scotland amounted to 913,231,000. In 1831 the number was 1,153,048,581. In 1840 the number rose to 1,725,628,333.

A common turnpike road bridge over a railway requires for its construction, in round numbers, 300,000 bricks; and the lining of a railway tunnel of ordinary dimensions consumes about 8,000 for every yard in length, or in round numbers about 14,000,000 per mile.

X. The processes employed in the manufacture of bricks differ very greatly in various parts of the country. In some districts the clay is ground between rollers, and the pugmill is never used. In others, both rollers and pugmills are employed. In the neighbourhood of London the clay is commonly passed through a washmill. Equal differences exist in the processes of moulding and drying. Lastly, the form of the kiln varies greatly. In many places the common Dutch kiln is the one employed. In Essex and Suffolk the kilns have arched furnaces beneath their floors; in Staffordshire bricks are fired in circular domed ovens called cupolas; whilst near London kilns are not used, and bricks are burnt in clamps, the fuel required for their vitrification being mixed up with the clay in the process of tempering.

XI. Bricks vary very much in their strength, a point to which, although of considerable importance, very little attention is paid. There is a striking difference in this respect between modern and ancient bricks; a difference very much in favour of those made centuries ago; and, perhaps, the weakest bricks made are supplied by London makers. In some experiments by Mr. Hawkes (a detailed account of which is given in the *Builder* for 1861) it was found that of thirty-five kinds of bricks which were tested, the average strength of the strongest was 2,855 lbs.; of those of medium tenacity, 2,125 lbs.; and of those of least strength, 1557 lbs. These bricks were of the ordinary form, and varied in thickness from 3·25 to 1·7 inches. It was also found that the thinner kinds of bricks were proportionally stronger than those which were thicker; the greatest, mean, and least strengths of the former being respectively 4,088 lbs., 2,954 lbs., and 2,070 lbs.

In comparing weight with strength, it was found that the average weight of twenty-five bricks from different districts, was 7·85 lbs., and that the heaviest bricks were usually the strongest. The results of the following experiments are calculated according to a uniform standard:—Tipton blue bricks, weighing 10 lbs., gave 5,555 lbs., 3,975 lbs., and 2,801 lbs., as the greatest, mean, and least degree of strength. Boston bricks, weighing 9·88 lbs., gave 4,133 lbs., 3,198 lbs., and 2,616 lbs., as the value of the same items. Roman hypocaust tiles from the ancient city of Uriconium, near Wroxeter, gave 4,670 lbs., 3,567 lbs., and 2,630 lbs. The Leeds bricks, weighing 9·17 lbs., gave 4,133 lbs., 3,198 lbs., and 2,616 lbs. Dutch clinkers, with a weight of only 6·56 lbs., gave the respective strength of 4,006 lbs., 3,345 lbs., and 2,542 lbs. This is an exception to the general result of the heaviest bricks being the strongest. Lastly, the lightest London bricks, weighing 6·19 lbs., gave 1,496 lbs., 998 lbs., and 366 lbs. The experiments also gave evidence of the fact that bricks were unable to sustain for any length of time a weight considerably less than that which was originally required to break them; for example, a Baltimore brick, which required 850 lbs. to break it, carried a weight of 735 lbs. for ten hours only, and then broke. It must be borne in mind that the second result is represented in terms of the whole brick, for the sake of rendering the comparison more easy, although, of course, the experiment could only be made on the half brick.

XII. The following report of the results of some experiments with Messrs. Burton & Co.'s hydraulic press, on hand-made and machine-made bricks respectively, will be found interesting. All the bricks were bedded upon a thickness of felt, and laid upon an iron-faced plate.

	Pressure to crack. tons.	Pressure to crush. tons.
Good London grey stocks	12·00	14·00
Best paviours to be got	14·00	23·00
Red bricks, not fully burnt	13·75	25·05
Ditto, ordinary quality	13·00	26·25
Three white bricks made by Clayton and Co.'s machinery	17·05	41·05
Ditto, second best, with four bricks	16·25	41·00

XIII. In connection with the question of the strength of brickwork, it may be mentioned that some elaborate and careful experiments have recently been made at the instance of the Royal Institute of British Architects, with the view of ascertaining the actual crushing strength of various kinds of bricks now (1898) in general use, built in lime mortar and also in cement mortar. These experiments were made with the utmost care, and every precaution was taken to ensure that the tests should be accurate and reliable.

It would be impossible to give here all the results obtained, but they may be briefly summarised from the "Journal of the Royal Institute of British Architects," of December, 1897. It was found that the average crushing load in *tons* per square foot of piers, increasing about 27 × 18 inches and 6 feet high, was for—

	Bricks alone.	Brickwork built in Lime.	Brickwork built in Cement.
Sittingbourne Stocks	84·27	18·63	39·29
Burham Gaults .	189·20	31·14	51·34
Flettons . .	220·85	30·68	56·25
Leicester Reds .	362·10	45·36	83·36
Blue Staffordshires	779 60	114·34	135·43

The extra strength obtained by the use of cement, instead of lime, mortar is very striking, especially as regards the weaker kinds of bricks.

"It is interesting," says the Journal, "to note the great difference between the strength of bricks and of brickwork, the enormous disproportion being due to the quality of the material interwoven with the bricks as a means of uniting and holding the mass together —if the mortar be imperfectly mixed, or the joints and beds of the brickwork imperfectly filled up, the injurious effect upon strength is incalculable."

As regards the practical question of the weight that may be safely imposed upon brickwork, the Journal observes:—

"If we take a safe load or one that would not materially damage the structure as one-fifth of the crushing load, it may be assumed from the results obtained that in lime mortar mixed 1 to 2 stock brickwork is equal to about 3½ tons, Gault 6 tons, Fletton 6 tons, Leicester Red 9 tons, and Staffordshire Blue 23 tons *per square foot*. In Portland cement mortar mixed 1 to 4 stocks would be equal to about 8 tons, Gaults

13 tons, Flettons 11 tons, Leicester Red 17 tons, and Staffordshire Blue 24 tons *per square foot.*

"This is only a general assumption which requires further consideration."

In the following pages we have described at considerable length the practice of brickmaking as carried on in Nottinghamshire, Staffordshire, Suffolk, and in the neighbourhood of London; and although the practice of almost every county presents some local peculiarity, the reader who has carefully gone through these accounts will be enabled to understand the object of any processes not here described, and to form a tolerably correct judgment as to whether the process of manufacture in any district is conducted in a judicious manner; or whether the brickmaker has merely followed the practices handed down by his predecessors without any consideration as to the possibility of improving upon them. Before, however, entering upon the practical details of the subject, it is necessary that the reader should have some knowledge of the general principles of brickmaking, and of the nature of the processes employed; and these we shall proceed to consider in the following chapter.

CHAPTER I.

GENERAL PRINCIPLES OF THE MANUFACTURE OF BRICKS AND TILES.

1. BRICKS.

1. The whole of the operations of the brickmaker may be classed under five heads, viz.:—

Preparation of brick earth.
Tempering.
Moulding.
Drying.
Burning.

We propose in this chapter to describe these operations one by one, pointing out the object to be effected by each, and comparing at the same time the different processes employed in various parts of this country for the same end.

PREPARATION OF BRICK EARTH.

2. The qualities to be aimed at in making bricks for building purposes may be thus enumerated:—Soundness, that is, freedom from cracks and flaws; hardness, to enable them to withstand pressure and cross strain; regularity of shape, that the mortar by which they are united may be of uniform thickness to insure uniformity of settlement; uniformity of size, that all the bricks in a course may be of the same height; uni-

formity of colour, which is of importance only in ornamental work; facility of cutting, to enable the bricklayer to cut them to any given shape, as required in executing all kinds of gauged work; lastly, for furnace-work, and all situations exposed to intense heat, infusibility.

3. Success in attaining the desired end depends chiefly on a proper selection of brick earths; their judicious preparation before commencing the actual process of brickmaking, as well as on the drying and burning of the bricks. The other operations are matters of minor importance. Brickmaking may be viewed in two lights—as a science, and as an art. The former has been little studied, and is imperfectly understood; whilst the latter has been brought to great perfection.

4. The argillaceous earths suitable for brickmaking may be divided into three principal classes, viz.:—

Pure clays, composed chiefly of alumina and silica, but containing a small proportion of other substances—as iron, lime, &c.* (See Appendix II., page 263.)

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* The following analyses of various kinds of clay are given in the second volume of the English translation of "Knapp's Technological Chemistry."

	Cornish washed Kaolin.	Stour-bridge fire clay.	Pipe clay.	Sandy clay.	Blue clay.	Brick clay.
Silica .	46·32	64·10	53·66	66·68	46·38	49·44
Alumina	39·74	23·15	32·00	26·08	38·04	34·26
Oxide of iron	0·27	1·85	1·35	1·26	1·04	7·74
Lime .	0·36	——	0·40	0·84	1·20	1·48
Magnesia	0·44	0·95	trace	trace	trace	5·14
Potash & soda	12·67	——	——	——	——	——
Water .		10·00	12·08	5·14	13·57	1·94
	99·80	100·05	99·49	100·00	100·23	100·00

Marls, which may be described as earths containing a considerable proportion of lime.

Loams, which may be described as light sandy clays.

It very seldom happens that earths are found which are suited for the purpose of brickmaking without some admixture. The pure clays require the addition of sand, loam, or some milder earth; whilst the loams are often so loose that they could not be made into bricks without the addition of lime to flux and bind the earth. Even when the clay requires no mixture, the difference in the working of two adjacent strata in the same field is often so great that it is advisable to mix two or three sorts together to produce uniformity in the size and colour of the bricks.

5. It appears, then, that a chemical compound of silica and alumina is the principal ingredient in all brick earth.* This silicate of alumina, or pure clay alone, or those clays which contain but little sand, may, when beaten up with water into a stiff paste, be moulded with great ease into any shape; but will shrink and crack in drying, however carefully and slowly the operation be conducted; and will not stand firing, as a red heat causes the mass to rend and warp, although it becomes very hard by the action of the fire.

The addition of any substance which will neither combine with water, nor is subject to contraction, greatly remedies these defects, whilst the plastic quality of the clay is not materially affected. For this reason the strong clays are mixed with milder earth or with sand. The loams and marls used for brickmaking in the neighbourhood of London are mixed with lime and sifted breeze for the same purpose, and also to effect the fluxing of the earth, as will be presently described.

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* Some remarks on the plasticity of clay will be found in the Appendix.

6. *Fire clays* or *refractory clays* are compounds of silica, alumina, and water, or hydrated silicates of alumina represented by the formula $Al_2O_3, 2SiO_3 + 2H_2O$. Such clays owe their refractory qualities to their comparative freedom from lime, magnesia, metallic oxides, and similar substances which act as fluxes. Few clays, however, exist in nature according to this pure type. The composition and quality of clays in contiguous beds in the same pit, and even of clay from the same contiguous horizontal bed, may vary. "If we compare different clays together in respect to elementary composition, we find the relation between the silica and alumina to be extremely variable, and accordingly, the formulæ which have been proposed to express their rational constitution are very discordant. This is in great measure to be explained by the fact, that in many clays a large proportion of silica exists uncombined either as sand, or in a much finer state of division. The grittiness of a clay is due to the presence of sand."* Fire-bricks are used in those parts of furnaces where the heat would soon destroy ordinary bricks. They are made of various shapes and sizes as required, and are often produced, as in the iron works of South Wales, on the spot. The clay is ground between rolls, or under edge stones, and kneaded by treading. The bricks are made by hand in moulds; they are carefully dried in stoves, and burnt at a high temperature in closed kilns. Burnt clay in powder is sometimes mixed with the raw clay. Stourbridge clay is celebrated for the manufacture of fine bricks, but clay from the coal-measures is also largely used. All these bricks have a pale brownish colour, but they are sometimes mottled with dark spots,

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* "Metallurgy," by John Percy, M.D., F.R.S., Lecturer on Metallurgy at the Government School of Mines. London, 1861.

which Dr. Percy refers to the presence of particles of iron pyrites. The *Dinas fire-brick* consists almost entirely of silica, the material being obtained from the rock of that name in the Vale of Neath. It lies on the limestone, and occasionally intermixes with it, and contains probably about 5 per cent. of calcareous matter. The bricks have extraordinary fire-proof qualities. The material had long been used as a sand, and many attempts were made to form it into bricks, without success, until a method was contrived by the late Mr. W. W. Young, when in 1822 a company was formed for the manufacture of these bricks. The mode of making the Dinas brick was long kept secret, but a number of original details concerning it are given in Dr. Percy's work. The material which is called *clay* is found at several places in the Vale of Neath in the state of rock, and disintegrated like sand. The colour when dry is pale grey. The rock is crushed to coarse powder between iron rolls; it softens by exposure to the air, but some of it is too hard to be used. "The powder of the rock is mixed with about 1 per cent. of lime and sufficient water to make it cohere slightly by pressure. This mixture is pressed into iron moulds, of which two are fixed under one press, side by side. The mould, which is open at the top and bottom, like ordinary brick-moulds, is closed below by a moveable iron plate, and above by another plate of iron, which fits in like a piston, and is connected with a lever. The machine being adjusted, the coarse mixture is put into the moulds by a workman, whose hands are protected by stout gloves, as the sharp edges of the fragments would otherwise wound them: the piston is then pressed down, after which the moveable bed of iron on which the brick is formed is lowered and taken away with the brick upon it, as it is not sufficiently solid to admit of being carried in the usual manner. The bricks are dried on these plates upon floors warmed by flues passing underneath; and when dry they are piled in a circular closed kiln covered with a dome, similar to kilns in which common fire bricks are burned. About seven days of hard firing are required for these bricks, and about the same time for the cooling of the kiln. One kiln contains 32,000 bricks, and consumes 40 tons of coal, half free-burning and half binding. The fracture of one of these bricks shows irregular particles of quartz, and the lime which is added acts as a flux, causing them to agglutinate. These bricks *expand* by heat, while bricks made of fire clay *contract*. Hence they are useful for the roofs of reverberatory furnaces, and for parts where solid and compact lining is required. These siliceous bricks must not be exposed to the action of slags rich in metallic oxides.

7. Fire clay, being an expensive article, is frequently mixed with burnt clay, often as much as two parts by weight to one of Stourbridge clay. Broken crucibles, old fire bricks, and old glass-pots ground to powder are also mixed with fire clay.

8. Fire clay is found throughout the coal measures, but that of Stourbridge is considered to be the best, as it will bear the most intense heat that can be produced without becoming fused. Next in esteem to those of Stourbridge are the Welsh fire bricks, but they will not bear such intense heat. Excellent fire bricks are made at Newcastle and Glasgow.

Fire bricks were formerly made near Windsor, at the village of Hedgerly, from a sandy loam known by the name of Windsor loam, and much used in London for fire-work, and also by chemists for luting their furnaces, and for similar purposes.

The relative merits of Silica, Welsh, Stourbridge, and other fire bricks, are best shown by their commercial value. The following items, extracted from Lockwood's "Builders' and Contractors' Price Book for 1898," edited by F. T. W. Miller, exhibit their relative cost:—

	Per 1000. £	s.	d.
Castle Cary fire bricks	6	0	0
Welsh ditto	5	10	0
Stourbridge ditto	5	10	0
Newcastle ditto	5	0	0
Silica ditto	7	10	0
Red Yorkshire oven ditto	3	15	0

9. Bricks made of refractory clay, containing no lime or alkaline matter, are *baked* rather than burnt; and their soundness and hardness depend upon the fineness to which the clay has been ground, and the degree of firing to which it has been exposed.

10. It is very seldom that the common clays are found to be free from lime and other fluxes; and when these are present in certain proportions, the silica of the clay becomes fused at a moderate heat, and cements the mass together. Some earths are very fusible, and, when used for brickmaking, great care is requisite in firing the bricks to prevent them from running together in the kiln.

11. The earths used for brickmaking near London are not clays, but loams and marls. To render these earths fit for brickmaking, they are mixed with chalk ground to a pulp in a wash-mill. This effects a double purpose, for the lime not only imparts soundness to the bricks, acting mechanically to prevent the clay from shrinking and cracking, but also assists in fusing the

siliceous particles; and when present in sufficient quantity, corrects the evil effects of an overdose of sand, as it takes up the excess of silica that would otherwise remain in an uncombined state.

12. It will be seen from these remarks that we may divide bricks generally into two classes—*baked* bricks made from the refractory clays, and *burnt* or vitrified bricks made from the fusible earths.

The fusible earths are the most difficult of treatment, as there is considerable practical difficulty in obtaining a sufficient degree of hardness without risking the fusion of the bricks; and it will be found that ordinary kiln-burnt bricks, made from the common clays, are for the most part of inferior quality, being hard only on the outside, whilst the middle is imperfectly burnt, and remains tender. The superior quality of the London malm bricks, which are made from a very fusible compound, is chiefly due to the use of sifted breeze,* which is thoroughly incorporated with the brick earth in the pugmill, so that each brick becomes a kind of fire ball, and contains in itself the fuel required for its vitrification. In building the clamps the bricks are stacked close together, and not as in ordinary kiln-burning, in which openings are left between the bricks to allow of the distribution of the heat from the live holes. The effect of these arrangements is to produce a steady uniform heat, which vitrifies the bricks without melting them. Those bricks which are in contact with the live holes or flues melt into a greenish black slag.

13. *Cutters*, that is, bricks which will bear cutting and rubbing to any required shape, are made from sandy loams, either natural or artificial. In many

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* Breeze is a casual mixture of cinders, small coal, and ashes, such as is collected by the dustmen.

districts cutters are not made, there being no suitable material for the purpose. Bricks made from pure clays containing but little silica are hard and tough, and will not bear cutting.

14. We now come to the consideration of colour, which depends on the varying proportions of the hydrated oxide of iron in the clay, which change according to the amount of heat to which the bricks are subjected, and not on their natural colour before burning. This should be borne in mind, because brickmakers often speak of clays as red clay, white clay, &c., according to the colour of the bricks made from them, without any reference to their colour in the unburnt state.

If iron be present in clay without lime or similar substances, the colour produced at a moderate red heat will be red, the intensity of colour depending on the proportion of iron. The bind or shale of the coal measures burns to a bright clear red. If the clay be slightly fusible, an intense heat vitrifies the outside of the mass and changes its colour, as in the case of the Staffordshire bricks, which, when burnt in the ordinary way, are of a red colour, which, however, is changed to a greenish blue by longer firing at a greater heat. The addition of lime changes the red produced by the oxide of iron to a cream brown, whilst magnesia brings it to a yellow. Few clays produce a clear red, the majority burning of different shades of colour, varying from reddish brown to a dirty red, according to the proportion of lime and similar substances which they contain. Some clays, as the plastic clays of Suffolk, Devonshire,* and Dorsetshire, burn of a clear white, as may be seen in the Suffolk white bricks, which are much esteemed for their soundness and colour. The London malms have a rich brimstone tint, which is greatly assisted by the nature of the sand used in the process of moulding.

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* The plastic clay of Devonshire and Dorsetshire forms the basis of the English stone ware. It is composed of about seventy-six parts of

15. By employing metallic oxides and the ochreous metallic earths, ornamental bricks are made of a variety of colours This, however, is a branch of brickmaking which has as yet received very little attention, although, with the rising taste for polychromatic decoration, it is well worthy of consideration. (See note, page 270.)

Yellow clampt burnt bricks are made in the vicinity of the metropolis, and in other situations where similar material and fuel are readily obtained. *White* bricks are made from the plastic clays of Devonshire and Dorsetshire, and also Cambridgeshire, Norfolk, Suffolk, and Essex, as well as in other counties. *Red* bricks are made in almost every part of England, notably in Leicestershire and near Peterborough, where immense quantities of machine-made bricks are annually turned out; the *fine red* or cutting brick is very largely made in Hampshire and Berkshire. *Blue* bricks are made in Staffordshire, and are much used in that part of England.

Sound and well-burnt bricks are generally of a clear and uniform colour, and when struck together will ring with a metallic sound. Deficiency in either of these points indicates inferiority.

16. Bricks sufficiently light to float in the water were known to the ancients. This invention, however, was completely lost until rediscovered at the close of the

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silica and twenty-four of alumina, with some other ingredients in very small proportions. This clay is very refractory in high heats, a property which, joined to its whiteness when burned, renders it peculiarly valuable for pottery, &c

last century by M. Fabbroni, who published an account of his experiments. M. Fabbroni succeeded in making floating bricks of an infusible earth called fossil meal, which is abundant in some parts of Italy. Bricks made of this earth are only one-sixth of the weight of common clay bricks, on which account they would be of great service in vaulting church roofs, and for similar purposes. Ehrenberg, the eminent German microscopist, showed that this earth consists almost entirely of the frustules or siliceous skeletons of various kinds of minute water plants. (See note, page 271.)

Having thus briefly sketched the leading principles which should be our guide in the selection of brick earth, we will now proceed to describe the several processes by which it is brought into a fit state for use.

17. *Unsoiling.*—The first operation is to remove the mould and top soil, which is wheeled away, and should be reserved for resoiling the exhausted workings when they are again brought into cultivation. In London the vegetable mould is called the *encallow,* and the operation of removing it, *encallowing.*

18. *Clay-digging and Weathering.*—The brick earth is dug in the autumn, and wheeled to a level place prepared to receive it, when it is heaped up to the depth of several feet, and left through the winter months to be mellowed by the frosts, which break up and crumble the lumps. At the commencement of the brickmaking season, which generally begins in April, the clay is turned over with shovels, and tempered either by spade labour or in the pugmill; sufficient water being added to give plasticity to the mass.

19. During these operations any stones which may be found must be carefully picked out by hand, which is a tedious and expensive operation, but one which

cannot be neglected with impunity, as the presence of a pebble in a brick generally causes it to crack in drying, and makes it shaky and unsound when burnt. If the earths to be used are much mixed with gravel, the only remedy is to wash them in a trough filled with water, and provided with a grating sufficiently close to prevent even small stones from passing through, and by means of which the liquid pulp runs off into pits prepared to receive it, where it remains until, by evaporation, it becomes sufficiently firm to be used. This process is used in making cutting bricks, which require to be of perfectly uniform texture throughout their whole substance; but it is tedious and expensive.

In working the marls of the midland districts, much trouble is experienced from the veins of skerry or impure limestone with which these earths abound. If a small piece of limestone, no bigger than a pea, is allowed to remain in the clay, it will destroy any brick into which it finds its way. The carbonic acid is driven off by the heat of the kiln, and forces a vent through the side of the brick, leaving a cavity through which water finds its way, and the first sharp frost to which such a brick may be exposed generally suffices to destroy the face.

20. *Grinding.*—To remedy this serious evil, cast-iron rollers are now generally used throughout the midland districts for grinding the clay and crushing the pieces of limestone found in it, and their introduction has been attended with very beneficial results. The clays of the coal measures contain much ironstone, which requires to be crushed in the same manner.

In many yards the grinding of the clay is made to form part of the process of tempering, the routine being as follows:—clay-getting, weathering, turning over and wheeling to mill, grinding, tempering, and moulding. In Staffordshire the clay is not only ground, but is also pugged in the process of tempering, as described in chap. iv. art. 38; the routine is then as follows:—clay-getting, grinding, weathering, turning over, pugging, moulding.

At a well-mounted brickwork in Nottingham, belonging to Moses Wood, Esq., the clay used in making the best facing bricks is treated as follows:—it is first turned over and weathered by exposure to frost; it is then again turned over, and the stones picked out by hand, after which it is ground between rollers set very close together, and then left in cellars to ripen for a year or more, before it is finally tempered for the use of the moulder. The bricks made from clay thus prepared are of first-rate quality, but the expense of the process is too great to allow of much profit to the manufacturer.

21. *Washing.*—The preparation of brick-earth in the neighbourhood of London is effected by processes quite different from those just described. For marl or *malm* bricks, the earth is ground to a pulp in a wash-mill, and mixed with chalk previously ground to the consistence of cream; this pulp, or, as it is technically called, malm, is run off through a fine grating into pits prepared to receive it, and there left, until by evaporation and settlement, it becomes of sufficient consistency to allow a man to walk upon it. It is then *soiled*, i.e. covered with siftings from domestic ashes, and left through the winter to mellow. At the commencement of the brickmaking season the whole is turned over, and the ashes thoroughly incorporated with the earth in the pugmill. In making common bricks, the whole of the earth is not washed, but the unwashed clay is

heaped up on a prepared floor, and a proportion of liquid malm poured over it, after which it is soiled in the same way as for making malms.

These processes are well calculated to produce sound, hard, and well-shaped bricks. The washing of the clay effectually frees it from stones and hard lumps, whilst the mixing of the chalk and clay in a fluid state ensures the perfect homogeneousness of the mass, and enables the lime to combine with the silica of the clay, which would not be the case unless it were in a state of minute division.

22. There are very few earths suitable in their natural state for making cutters. They are therefore usually made of washed earth mixed up with a proportion of sand. Without the addition of sand the brick would not bear rubbing, and it would be very difficult to bring it to a smooth face.

23. It may be here observed that sufficient attention is not generally paid to the preparation of brick-earth, as it too frequently happens that the clay is dug in the spring instead of the autumn, in which case the benefit to be derived from the winter frosts is quite lost. The use of rollers, to a certain extent, counterbalances this; but bricks made of clay that has been thoroughly weathered are sounder and less liable to warp in the kiln.

TEMPERING.

24. The object of tempering is to bring the prepared brick earth into a homogeneous paste, for the use of the moulder.

The old-fashioned way of tempering was to turn the clay over repeatedly with shovels, and to tread it over by horses or men, until it acquired the requisite plasticity. This method is still practised in many country yards; but where the demand for bricks is extensive, machinery is usually employed, the clay being either *ground* between rollers or *pugged* in a pugmill. This latter process is also called grinding, and, therefore, in making inquiries respecting the practice of particular localities, the reader should be careful that he is not misled by the same name being applied to processes which are essentially different.

When rollers are used in the preliminary processes, the labour of tempering is much reduced. Their use is, however, most generally confined to the process of tempering, which is then effected as follows:—The clay, which has been left in heaps through the winter to mellow, is turned over with wooden shovels (water being added as required), and wheeled to the mill, where it is crushed between the rollers, and falls on a floor below them, where it is again turned over, and is then ready for use.

When the clay is sufficiently mild and free from lime and ironstone as not to require *crushing*, tempering by spade labour and treading is generally adopted; but in the districts where rollers are used, the brick-earths are generally so indurated that a great proportion could not be rendered fit for use by the ordinary processes. The advantages and disadvantages of the use of rollers are considered at some length in chap. iii. art. 4.

25. In making bricks for railway works, which has been done lately to an almost incredible extent, contractors are generally little anxious as to the shape or appearance of the article turned out of the kiln, provided it be sufficiently sound to pass the scrutiny of the inspector or resident engineer. As the whole process of railway brickmaking often occupies but a few weeks from the first turning over of the clay to the laying of

the bricks in the work, the use of rollers in such cases is very desirable, as a partial substitute for weathering. On the line of the Nottingham and Grantham Railway several millions of bricks have been made as follows:—The clay is first turned over with the spade, and watered and trodden by men or boys, who, at the same time, pick out the stones. It is then wheeled to the mill and ground; after which it is turned over a second time, and then passed at once to the moulding table.

26. Although in many country places, where the demand for bricks is very small, tempering is still performed by treading and spade labour, the pugmill is very extensively used near London, and in most places where the brick-earth is of mild quality, so as not to require crushing, and the demand for bricks sufficiently constant to make it worth while to erect machinery. The pugmill used near London is a wooden tub, in shape an inverted frustrum of a cone, with an upright revolving shaft passing through its centre, to which are keyed a number of knives, which, by their motion, cut and knead the clay, and force it gradually through the mill, whence it issues in a thoroughly tempered state, fit for the use of the moulder. Some contend that the pugmill is no improvement on the old system of tempering by manual labour; but, without entering into this question, there can be no doubt that it does its work very thoroughly, and its use prevents the chance of the tempering being imperfectly performed through the negligence of the temperers. In the London brickfields the process of tempering is conducted as follows:—The malm, or malmed brick-earth, as the case may be, is turned over with the spade, and the soil* (ashes) dug

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* Soil, *i.e.* *ashes*, must not be confounded with soil, *vegetable mould*, which is in some places mixed with strong clay, to render it milder.

into it, water being added as may be necessary. It is then barrowed to the pugmill, and being thrown in at the top, passes through the mill, and keeps continually issuing at a hole in the bottom. As the clay issues from the ejectment hole, it is cut into parallelopipedons by a labourer, and, if not wanted for immediate use, is piled up and covered with sacks to prevent it from becoming too dry.

In Staffordshire steam power is used for driving both rollers and pugmill, and the case of the latter is usually a hollow cast-iron cylinder.

MOULDING.

27. A brick-mould is a kind of box without top or bottom, and the process of moulding consists in dashing the tempered clay into the mould with sufficient force to make the clot completely fill it, after which the superfluous clay is *stricken* with a strike, and the newly-made brick is either turned out on a drying floor to harden, or on a board or pallet, on which it is wheeled to the hack-ground. The first mode of working is known as *slop moulding,* because the mould is dipped in water, from time to time, to prevent the clay from adhering to it. The second method may be distinguished as *pallet moulding;* and in this process the mould is not wetted, but sanded. These distinctions, however, do not universally hold good, because in some places slop-moulded bricks are turned out on pallets.

28. These differences may, at first sight, appear trivial, but they affect the whole economy of a brick-work. In slop moulding the raw bricks are shifted by hand from the moulding table to the drying floor, from the drying floor to the hovel or drying shed, and from

the hovel to the kiln. It is therefore requisite that the works should be laid out so as to make the distance to which the bricks have to be carried the shortest possible. Accordingly,* the kiln is placed in a central situation in a rectangular space, bounded on two or more sides by the hovel, and the working floors are formed round the outside of the latter.

In the process of slop moulding the newly-made brick is carried, mould and all, by the moulder's boy to the flat, or drying floor, on which it is carefully deposited; and whilst this is being done, the moulder makes a second brick in a second mould, the boy returning with the first mould by the time the second brick is being finished. As soon, therefore, as the floor becomes filled for a certain distance from the moulding table, the latter must be removed to a vacant spot, or the distance to which the bricks must be carried would be too great to allow of the boy's returning in time with the empty mould.

29. In pallet moulding but one mould is used. Each brick, as it is moulded, is turned out on a pallet, and placed by a boy on a hack-barrow, which, when loaded, is wheeled away to the hack-ground, where the bricks are built up to dry in low walls called hacks. One moulder will keep two wheelers constantly employed, two barrows being always in work, whilst a third is being loaded at the moulding stool. When placed on the barrow, it is of little consequence (comparatively) whether the bricks have to be wheeled 5 yards or 50; and the distance from the moulding stool to the end of the hacks is sometimes considerable.

30. The moulding table is simply a rough table, made

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* There are, of course, some exceptions; but, where practicable, the drying floors and hovel are placed close to the kilns.

in various ways in different parts of the country, but the essential differences are, that for slop moulding the table is furnished with a water trough, in which the moulds are dipped after each time of using; whilst in pallet moulding, for which the mould is usually sanded and not wetted, the water trough is omitted, and a *page* (see account of Brickmaking as practised in London) is added, on which the bricks are placed preparatory to their being shifted to the hack-barrow.

31. Brick moulds are made in a variety of ways. Some are made of brass cast in four pieces and riveted together; some are of sheet iron, cased with wood on the two longest sides; and others again are made entirely of wood, and the edges only plated with iron. Drawings and detailed descriptions of each of these constructions are given in the subsequent chapters. In using wooden moulds the slop-moulding process is almost necessary, as the brick would not leave the sides of the mould unless it were very wet. Iron moulds are sanded, but not wetted. Brass, or, as they are technically called, copper moulds, require neither sanding nor wetting, do not rust, and are a great improvement on the common wooden mould formerly in general use. They, however, are expensive, and will not last long, as the edges become worn down so fast that the bricks made from the same mould at the beginning and end of a season are of a different thickness, and cannot be used together. This is a great defect, and a metal mould which will not rust nor wear is still a great desideratum. It is essential that the sides of the mould should be sufficiently stiff not to *spring* when the clay is dashed into it, and it is equally requisite that it should not be made too heavy, or the taking-off boy would not be able to carry it to the floor. A common

copper mould weighs about 4 lbs., and, with the wet brick in it, about 12 lbs., and this weight should not be exceeded.

32. There is a great difference in the quantity of bricks turned out in a given time by the pallet moulding and by the slop moulding processes. In slop moulding 10,000 per week is a high average, whilst a London moulder will turn out 36,000 and upwards in the same period. This arises in a great measure from the circumstance that in pallet moulding the moulder is assisted by a clot moulder, who prepares the clot for dashing into the mould; whilst in slop moulding the whole operation is conducted by the moulder alone.

33. In some places the operation of moulding partakes both of slop moulding and pallet moulding, the bricks being turned out on pallets and barrowed to the hack-ground, whilst the moulds are wetted as in the ordinary process of slop moulding.

34. The substitution of machinery for manual labour in the process of moulding has long been a favourite subject for the exercise of mechanical talent; but although a great number of inventions have been patented, there are very few of them that can be said to be thoroughly successful. The actual cost of moulding bears so small a proportion to the total cost of brickmaking, that in small brickworks the employment of machinery would effect no ultimate saving, and, therefore, it is not to be expected that machinery will ever be generally introduced for brick moulding. But in works situated near large towns, or in the execution of large engineering works, the case is very different, and a contractor who requires, say, 10,000,000 of bricks, to be made in a limited time, for the construction of a tunnel or a viaduct, can employ machinery with great

advantage. A chapter on brickmaking machines will be found in another part of this volume.

35. It has been much discussed by practical men, whether bricks moulded under great pressure are better than those moulded in the ordinary way. They are of denser texture, harder, smoother, heavier, and stronger than common bricks. On the other hand, it is difficult to dry them, because the surfaces become over-dried and scale off before the evaporation from the centre is completed. Their smoothness lessens their adhesion to mortar; and their weight increases the cost of carriage, and renders it impossible for a bricklayer to lay as many in a given time as those of the ordinary weight. On the whole, therefore, increased density may be considered as a disadvantage, although, for some purposes, dense bricks are very valuable.

36. Mr. Prosser, of Birmingham, has introduced a method of making bricks, tiles, and other articles by machinery, in which no drying is requisite, the clay being used in the state of a nearly dry powder. The clay from which floor-tiles and tesseræ are made is first dried upon a slip-kiln,* as if for making pottery, then ground to a fine powder, and in that state subjected to heavy pressure† in strong metal moulds: by this means the clay is reduced to one-third of its original thickness, and retains sufficient moisture to give it cohesion. The articles thus made can be handled at once, and carried direct to the kiln. In some experiments tried for ascertaining the resistance of bricks and tiles thus made to

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* The *slip-kiln* is a stone trough bottomed with fire tiles, under which runs a furnace flue. It is used in the manufacture of pottery for evaporating the excess of water in the *slip*, or liquid mixture of clay and ground flints, which is thus brought into the state of paste.

† It is a common but an erroneous notion, that articles made by Mr. Prosser's process are denser than similar articles made in the common way: the reverse is the fact.

a crushing force, a 9-inch brick sustained a pressure of 90 tons without injury.

37. Mr. Prosser's method offers great advantages for the making of ornamental bricks for cornices, bas-reliefs, floor-tiles, tesselated pavements, &c. Screw presses are used to a considerable extent for pressing bricks when partially dry, to improve their shape and to give them a smooth face; but we have in many instances found pressed bricks to *scale* on exposure to frost, and much prefer dressing the raw brick with a beater, as described in chap. iii. art. 34.

38. The great practical difficulty in making moulded bricks for ornamental work is the warping and twisting to which all clay ware is subject more or less in the process of burning. This difficulty is especially felt in making large articles, as wall copings, &c. In moulding goods of this kind it is usual to make perforations through the mass, to admit air to the inside, without which precaution it would be impossible to dry them thoroughly; for, although the outside would become hard, the inside would remain moist, and, on being subjected to the heat of the kiln, the steam would crack and burst the whole.

The Viaduct, on the Brighton and South Coast Railway, has a massive white brick* dentil cornice, the bricks for which were made in Suffolk after several unsuccessful attempts to make bricks of still larger size. The thickness of the bricks first proposed presenting an insurmountable obstacle to their being properly dried, their dimensions were reduced, and large perforations were made in each brick to reduce its weight, and to enable it to be more thoroughly and uniformly dried;

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* Brick was preferred to stone on account of the expense of the latter material.

and by adopting this plan the design was successfully carried into execution.

39. The usual form of a brick is a parallelopipedon, about 9 in. long, 4½ in. broad, and 3 in. thick, the exact size varying with the contraction of the clay. The thickness need not bear any definite proportion to the length and breadth, but these last dimensions require nice adjustment, as the length should exceed twice the breadth by the thickness of a mortar joint.

40. Bricks are made of a variety of shapes for particular purposes, as enumerated in art. 60, chap. iii. The manufacture of these articles is principally carried on in the country, the brickfields in the vicinity of the metropolis supplying nothing but the common building brick.

41. A point of some little importance may be here adverted, to, viz., is any advantage gained by forming a hollow in the bed of the brick to form a key for the mortar? There are various opinions on this point; but we think it may be laid down as a principle, that if it is useful on one side it will be still better on both, so as to form a double key for the mortar. In London, the brick mould is placed on a stock board, which is made to fit the bottom of the mould; and the relative positions of the two being kept the same, no difficulty exists in forming a hollow on the bottom of the brick, this being effected by a *kick* fastened on the stock board. But this could not be done on the *upper* side, which is stricken level. In slop moulding, the mould is simply laid on the moulding stool, or on a moulding board much larger than the mould, and both sides of the brick are flush with the edges of the mould, no hollow being left, unless the moulder think fit to make one by scoring the brick with his fingers, which is sometimes done. When machinery is used in moulding, it is equally easy

to stamp the top and the bottom of the brick; and we have seen, at the Butterly Ironworks, in Derbyshire, excellent machine-made bricks of this kind made in the neighbourhood.

42. Amongst the many inventions connected with brickmaking which have been from time to time brought before the public, *ventilating* bricks deserve attention, from the facilities they afford for warming and ventilating buildings.

The annexed figures show the form of the bricks and the way in which they are used.

Fig. 1.

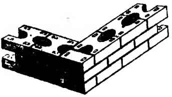

Fig. 2.

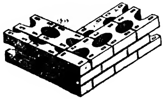

Fig. 3.

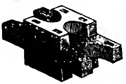

Fig. 1 is a representation of a 9-in. wall, built with the ventilating bricks, with one common brick used at the angle of each course.

Fig. 2 is a representation of a 14-in. wall; the half ventilating brick, being used alternately in the courses, forms a perfect and effectual bond.

Fig. 3 is an isometrical drawing showing the ventilating spaces.

DRYING.

43. The operation of drying the green bricks requires great care and attention, as much depends upon the

manner in which they are got into the kiln. The great point to be aimed at is to protect them against sun, wind, rain, and frost, and to allow each brick to dry uniformly from the face to the heart.

Slop-moulded bricks are usually dried on flats or drying floors, where they remain from one day to five or six, according to the state of the weather. When spread out on the floor they are sprinkled with sand, which absorbs superfluous moisture, and renders them less liable to be cracked by the sun's rays. After remaining on the floors until sufficiently hard to handle without injury, they are built up into hacks under cover, where they remain from one to three weeks, until ready for the kiln. In wet weather they are spread out on the floor of the drying shed, and great care must then be taken to avoid drafts, which would cause the bricks to dry faster on one side than the other. To prevent this, boards set edgeways are placed all round the shed to check the currents of air.

The quantity of ground required for drying bricks in this manner is comparatively small, as they remain on the floors but a short time, and occupy little space when hacked in the hovels. The produce of a single moulding stool by the slop-moulding process seldom exceeds 10,000 per week, and the area occupied by each stool is, therefore, small in proportion. Half an acre for each kiln may be considered ample allowance for the working floor and hovel.

44. In places where brickmaking is conducted on a large scale, drying sheds are dispensed with, and the hacks are usually built in the open air, and protected from wet, frost, and excessive heat, by straw, reeds, matting, canvas screens, or tarpaulins; all of which we have seen used in different places.

45. Bricks intended to be clamp burnt are not dried on flats, but are hacked at once on leaving the moulding stool, and remain in the hacks much longer than bricks intended to be kilned. This is rendered necessary by the difference between clamping and kilning. In the latter mode of burning, the heat can be regulated to great nicety, and if the green bricks, when first placed in the kiln, be not thoroughly dried, a gentle heat is applied until this is effected. In clamping, however, the full heat is attained almost immediately, and, therefore, the bricks must be thoroughly dried, or they would fly to pieces. In the neighbourhood of London a good moulder, with his assistants, will turn out from 30,000 to 40,000 bricks per week, and the clamps contain from 60,000 to 120,000 bricks and upwards.

From these combined causes, the area occupied by each stool is greater than in making slop-moulded bricks. In Mr. Bennett's brick-ground at Cowley, ten stools occupy twenty acres.

46. At the risk of wearying the patience of the reader, we recapitulate the leading points on which depends the difference of area required for each moulding stool in making:—

Slop-moulded bricks, hacked under cover, and burnt in kilns.		London pallet-moulded sand stocks, burnt in clamps.
Dried one day on flats . . .	1st	Hacked at once.
Closely stacked in hacks 17 courses high, placed close together under cover . . .	2nd	Bricks loosely stacked in hacks, 8 courses high and 2 bricks wide, with 9 ft. spaces between the hacks.
Remain in shed 10 to 16 days	3rd	Remain in hacks 3 to 6 weeks.
Rate of production per stool, about 10,000 weekly . . .	4th	A gang will turn out 30,000 to 40,000 per week.
Kiln holds about 30,000 bricks, and may be fired once in 10 days	5th	Clamp contains 60,000 to 120,000 bricks, and burns from 2 to 6 weeks.

47. It is scarcely necessary to observe that different

clays require different treatment, according to their composition, some bricks bearing exposure to sun and rain without injury, whilst others require to be carefully covered up to keep them from cracking under similar circumstances. [See Appendix.]

Superior qualities of bricks are generally *dressed* with a beater when half dry, to correct any twisting or warping which may have taken place during the first stage of drying.

BURNING.

48. Bricks are burnt in *clamps* and in *kilns*. The latter is the common method, the former being only employed in burning bricks made with ashes or coal-dust. It should be observed, however, that the name of clamp is applied also to a pile of bricks arranged for burning in the ordinary way, and covered with a temporary casing of burnt brick to retain the heat; but this must not be confounded with close-clamping as practised in the neighbourhood of London.

49. The peculiarity of clamp burning is that each brick contains in itself the fuel necessary for its vitrification; the breeze or cinders serving only to ignite the lower tiers of bricks, from which the heat gradually spreads over the whole of the clamp. No spaces are left between the bricks, which are closely stacked, that the heat to which they are exposed may be as uniform as possible. It is unnecessary here to go into the details of clamping, as they are very fully given in the account of London Brickmaking. [See also Appendix.]

50. A *kiln* is a chamber in which the green bricks are loosely stacked, with spaces between them for the passage of the heat; and baked by fires placed either

in arched furnaces under the floor of the kiln, or in fire holes formed in the side walls.

There are many ways of constructing kilns, and scarcely any two are exactly alike; but they may be divided into three classes:—

1st. The common rectangular kiln with fire-holes in the side walls. This is formed by building four walls enclosing a rectangular space, with a narrow doorway at each end, and narrow-arched openings in the side walls exactly opposite to each other. The bricks are introduced through the doorways, and loosely stacked with considerable art, the courses being crossed in a curious manner, so as to leave continuous openings from top to bottom of the pile to distribute the heat. In the lower part of the kiln narrow flues are left, about 8 in. wide and about 2 ft. or 3 ft. high, connecting the fire-holes in the side walls. The kilns having been filled, the doorways are bricked up and plastered with clay to prevent the ingress of cold air; the top of the kiln is covered with old bricks, earth, or boards, to retain the heat, and the firing is carried on by burning coal in the fire-holes. A low shed is generally erected on each side of the kiln to protect the fuel and fireman from the weather, and to prevent the wind from urging the fires. The details of the management of a kiln are given in another place, and need not be here repeated. This kind of kiln is he simplest that can well be adopted, and is in use in Holland at the present day. It is the kiln in common use through the Midland districts.

2nd. The rectangular kiln with arched furnaces. This consists also of a rectangular chamber; but differs from the first in having two arched furnaces running under the floor the whole length of the kiln, the furnace doors being at one end. The floor of the kiln is formed like lattice-work, with numerous openings from the furnaces below, through which the heat ascends. The top of the kiln is covered by a moveable wooden roof, to retain the heat, and to protect the burning bricks from wind and rain. These kilns are used in the east of England.

3rd. The circular kiln or cupola. This is domed over at the top, whence its name is derived. The fire-holes are merely openings left in the thickness of the wall, and are protected from the wind by a wall built round the kiln at a sufficient distance to allow the fireman room to tend the fires. These cupolas are used in Staffordshire and the neighbourhood, and the heat employed in them is very great. Drawings of a cupola are given in chap. iv., with an account of the manner in which the firing is conducted, and therefore it is unnecessary to enter here upon any of these details.

51. The usual method of placing bricks in the kiln is to cross them, leaving spaces for the passage of the heat, but there are objections to this, as many bricks show a different colour, where they have been most exposed to the heat. Thus in many parts of the country, the bricks exhibit a diagonal stripe of a lighter tint than the body of the brick, which shows the portion that has been most exposed. In burning bricks that require to be of even colour, this is guarded against by placing them exactly on each other.

On first lighting a kiln the heat is got up gently, that the moisture in the bricks may be gradually evaporated.

When the bricks are thoroughly dried, which is known by the steam ceasing to rise, the fires are made fiercer, and the top of the kiln is covered up with boards, turf, old bricks, or soil, to retain the heat. As the heat increases, the mouths of the kiln are stopped to check the draft, and when the burning is completed, they are plastered over to exclude the air, and the fires are allowed to go out. After this the kiln is, or should be, allowed to cool very gradually, as the soundness of the bricks is much injured by opening the kiln too soon.

Pit coal is the fuel commonly used, and the quantity required is about-half a ton per 1,000 bricks; but much depends on the quality of the coal, the construction of the kiln, and the skill with which the bricks are stacked.

Wood is sometimes used as fuel in the preliminary stage of firing, but not to a great extent. In a letter received on the management of the Suffolk kilns, the writer says, "The usual mode of firing bricks in Suffolk is in a kiln. The one near me, belonging to a friend of mine, is constructed to hold 40,000; it is about 20 ft. long and 15 ft. broad, and is built upon two arched furnaces that run through with openings to admit the heat up. The bricks are placed in the usual way for burning, by crossing so as to admit the heat equally through, when the whole mass becomes red hot: the first three or four days, wood is burnt in what is called the process of annealing; with this they do not keep up a fierce fire. After this from 12 to 14 tons of coal are consumed in finishing the burning. Private individuals sometimes make and clamp 20,000 or 30,000 without a kiln; then there is great waste, and the bricks are not so well burnt.

52. In the preceding pages we have briefly sketched the operations of brickmaking, and the principles on which they depend. In the following chapters the reader will find these operations described in detail, as practised in different parts of the country; it need

hardly be said that the illustrations might be greatly extended, as there are scarcely two counties in England in which the processes are exactly similar, but this would lead us far beyond the limits of a Rudimentary Treatise, and enough is given to show the student the interest of the subject, and to enable him to think and examine for himself. If he be induced to do this from the perusal of these pages, the aim of this little volume will have been completely fulfilled.

II. TILES.

53. The manufacture of tiles is very similar to that of bricks, the principal differences arising from the thinness of the ware, which requires the clay to be purer and stronger, and renders it necessary to conduct the whole of the processes more carefully than in making bricks.

54. Tiles are of three classes, viz., paving tiles, roofing tiles, and drain tiles.

Paving tiles may be considered simply as thin bricks, and require no especial notice.

Roofing tiles are of two kinds: pantiles, which are of a curved shape, and plaintiles, which are flat, the latter being often made of ornamental shapes so as to form elegant patterns when laid on a roof.

Pantiles are moulded flat, and afterwards bent into their required form on a mould. Plain tiles were formerly made with holes in them for the reception of the tile-pins, by which they were hung on the laths; but the common method is now to turn down a couple of nibs at the head of the tile, which answer the same purpose.

Besides pantiles and plaintiles, hip, ridge, and valley tiles, come under the denomination of roofing tiles; these are moulded flat, and afterwards bent on a mould, as in making pantiles.

Draining tiles belong to the coarsest class of earthenware. They are of various shapes, and are made in various ways. Some are moulded flat, and afterwards bent round a wooden core to the proper shape. Others are made at once of a curved form, by forcing the clay through a mould by mechanical means. Tile-making machines are now almost universally superseding manual labour in this manufacture, and many machines of various degrees of merit have been patented during the last few years.

55. Besides the above articles, the business of a tilery includes the manufacture of tiles for malting floors, chimney-pots, tubular drains, and other articles of pottery requiring the lathe for their formation. We do not, however, propose now to enter upon the potter's art, which, indeed, would require an entire volume, but shall confine ourselves to the description of the manufacture of roofing tiles as made in Staffordshire, and at the London tileries, adding a few words on the making of tesseræ and ornamental tiles as practised by Messrs. Minton, of Stoke-upon-Trent.

56. In the country it is common to burn bricks* and tiles together, and as, in most places, the demand for bricks is not great, except in the immediate vicinity of large towns, where the demand is more constant, the manufacturer generally only makes so many bricks as are required to fill up the kiln.

Where there is a great and constant demand for bricks and tiles, their manufacture is carried on separately, and tiles are burnt in a large conical building, called a dome, which encloses a kiln with arched furnaces. There are many of these in the neighbourhood of London, and, as we have described them very fully in the chapter on London Tileries, we need say nothing further here on this subject.

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* In some places bricks and *lime* are burnt together.

57. The manufacture of draining tiles is one which daily assumes greater importance on account of the attention bestowed on agriculture, and the growing appreciation of the importance of thorough drainage. Any discussion on the best forms of draining tiles, or the most advantageous methods of using them, would, however, be out of place in this volume. Neither need we say much on the practical details of the manufacture, as it is exceedingly simple, and as regards the preparation of the clay, and the processes of drying and burning, is precisely similar to the other branches of tile-making. With regard to the process of moulding, there is little doubt but that hand moulding will soon be entirely superseded by machinery; and the discussion of the merits of the numerous excellent tile-making machines now offered to the public, although of great interest to those engaged in the manufacture, would be unsuited to the pages of a rudimentary work, even were it practicable to give the engravings which would be necessary to enable the reader to understand their comparative advantages or defects.* A few words on the principal features of the manufacture of drain tiles are, however, required to enable the reader to appreciate its peculiar character.

58. Bricks, paving tiles, and roofing tiles, are little required, and seldom manufactured, except in the neigh-

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* A few details will be found in the chapter on Brickmaking by Machinery.

bourhood of towns or of large villages, where the demand is likely to be sufficiently constant to warrant the erection of kilns, drying sheds, and other appurtenances of a well-mounted brickwork. If a cottage is to be rebuilt, a barn tiled, or it may be once in twenty or thirty years a new farmsteading erected in a rural district, it is generally cheaper to incur the expense of carting a few thousand bricks or tiles than to erect the plant necessary for making these articles on the spot.

But with drain tiles the case is reversed. They are most wanted precisely in situations where a brick-yard would be an unprofitable speculation, viz., in the open country, and often in places where the cost of carriage from the nearest brick-yard would virtually amount to a prohibition in their use, if they cannot be made on the spot, and that at a cheap rate. What is wanted, therefore, is a good and cheap method of making drain tiles without much plant, and without erecting an expensive kiln, as the works will not be required after sufficient tiles have been made to supply the immediate neighbourhood, and therefore it would not be worth while to incur the expense of permanent erections. The making drain tiles a *home manufacture* is, therefore, a subject which has much engaged the attention of agriculturists during the last few years, and it gives us great pleasure to be enabled to give engravings of a very simple and effective tile-kiln erected by Mr. Law Hodges, in his brick-yard, and described in the *Journal of the Royal Agricultural Society*, vol. v., part 2, from which publication we have extracted so much as relates to the description of this kiln, and the cost of making drain tiles in the manner recommended by him. [See Appendix.]

59. We have already extended this sketch of the general principles and practice of brick and tile making beyond its proper limits, and must therefore pass on to the practical illustrations of our subject.

The chapter "On the Manufacture of Bricks and Tiles in Holland" is reprinted from the third volume of Weale's "Quarterly Papers on Engineering," and will be read with interest on account of the great similarity of the English and Dutch processes.

The account of brickmaking, as practised at Nottingham and the Midland counties, was written from personal examination of brickworks in the vicinity of Nottingham, and in the counties of Derby, Leicester, and Lincoln, and has been carefully revised by a gentleman long connected with one of the principal brickworks near Nottingham.

The paper "On Brickmaking, as practised in the Staffordshire Potteries," was contributed to this volume by Mr. R. Prosser, of Birmingham, whose name is a sufficient guarantee for the value of the information therein contained. The details for this paper were collected by Mr. Prosser's assistant, Mr. John Turley, of Stoke; and the valuable analyses of brick-earths were made for Mr. Prosser by Mr. F. C. Wrightson, of Birmingham, at a considerable expense.

The description of brickmaking in the vicinity of London has been drawn up with great care, and is the first illustrated account that has yet appeared of the manufacture of clamp bricks. The drawings accompanying this paper, and that on the London Tileries, are from the pencil of Mr. B. P. Stockman.

Professional engagements preventing a personal examination of the processes employed in brick and tile-making in the vicinity of the metropolis, Mr. Stockman kindly undertook this task, and to his persevering energy and talent we are indebted for a great mass of practical details embodied in these two chapters.

Lastly, in the Appendix are inserted various particulars relative to brickmaking which could not have been introduced in any other part of the volume without interrupting the continuity of the text.

CHAPTER II.

ON THE MANUFACTURE OF BRICKS AND TILES IN HOLLAND. BY HYDE CLARKE, C.E.

I.—BRICKS.

THE Dutch make a most extensive use of bricks, of which they have several kinds. Not only are bricks used for ordinary building purposes, and for furnaces, but also in great quantities for foot pavements, towing-paths, streets, and high roads. It may be observed, that they have of late been used very effectively in this country for the pavement of railway stations. The paving bricks, or Dutch clinkers, are the hardest sort, and are principally manufactured at Moor, a smal village about two miles from Gouda, in South Holland. The brick-fields are on the banks of the river Yssel, from which the chief material is derived, being no other than the slime deposited by the river on its shores, and at the bottom. The slime of the Haarlem Meer is also extensively used for this purpose, as most travellers know. This is collected in boats, by men, with long poles having a cutting circle of iron at the end, and a bag-net, with which they lug up the slime. The sand is also obtained by boatmen from the banks of the river Maes. It is of a fine texture, and grayish colour. The hard bricks are made with a mixture of this slime and sand, but in what proportions I am not informed. River sand is recognised as one of the best materials for bricks, and is used by the London brickmakers, who obtain it from the bottom of the Thames, near Woolwich, where it is raised into boats used for the purpose. For what are called in France, Flemish bricks, and which are manufactured in France, Flanders, and on the corresponding Belgian frontier, river sand is preferred, and is obliged to be obtained from the Scheldt. At Ghent, and lower down, a considerable traffic is carried on in the supply of this material. The quantity used there is about one cubic foot of sand per cubic yard.

The slime and sand, being mixed, are well kneaded together with the feet, and particular attention is paid to this part of the process. The mixture is then deposited in heaps. The mode of moulding and drying is similar to that used elsewhere. Paving bricks are generally about 6 in. long, 4 in. broad, and 1¾ in. thick. Dutch clinks made in England are 6 in. long, 3 in. broad, and 1 in. thick.

The house bricks and the tiles are made for the most part at Utrecht, in the province of the same name, from brick earth found in the neighbourhood. House bricks are about 9½ in. long, 4½ in. wide, and nearly 2 in. thick.

II.—BRICK-KILNS.

The kilns are built of different sizes, but generally on the same plan. Sometimes they will take as many as 1,200,000 bricks. A kiln for burning 400,000 bricks at once is represented in the "Memoirs of the Academy of Sciences of France." It is a square of about 33 ft. or 35 ft. long by 28 ft. or 30 ft. wide, closed in with four walls of brick, 6 ft. thick at the base, and which slope upwards outside to their extreme height, which is about 18 ft. Some slope also slightly inwards, but in a different direction. Different plans are nevertheless adopted with regard to the form of the external walls, the great object being, however, to concentrate the heat as much as possible. In the walls, holes are left for six flue-holes, and sometimes for eight or ten or twelve. In one of the walls, in the breadth of the kiln, an arched doorway is made, about 6 ft. wide and 12 ft. high, by which the bricks are brought into the kiln. The arrangements as to the doorway are also subject to variation. The interior of the kiln is paved with the bricks, so as to present a level base. The walls are laid with mortar of the same earth from which the bricks are made, and with which they are also plastered inside; yet, notwithstanding the strength with which they are built, the great power of the kiln fire sometimes cracks them. The kilns, I would observe, are not usually covered in, but some of those for baking building-bricks have roofs made of planks, and without tiles, to shelter them from the wind and rain. Others are provided with rush mats, which are changed according to the side on which the wind blows. The matting also serves for protecting the bricks against the rain, whilst the kiln is being built up. A shed, or hangar, is put up on each side of the kiln, in order to contain the peat turf, or to shelter the fire-tender, and to preserve the fires against the effects of wind. Such being the practice with regard to roofing, when the bricks are put into the kiln, a layer, or sometimes two layers, of burnt bricks is placed on the floor, laid lengthwise, about three-quarters of an inch from each other, and so as to slope a little from the parallel of the walls, that they may the better support the upper rows, which are always laid parallel to the walls. This layer is covered with old rush mats, on which are arranged the dried bricks, which are laid without intervals between them. It is said that the mats serve to prevent the humidity of the soil from penetrating to the bricks while the kiln is being filled, which generally takes from about three weeks to a month. This row of burnt bricks is so placed as to leave channels or flues of communication with corresponding openings in the kiln walls. Six layers of dried bricks having been put down, the next three rows are made to jut over, so as to shut up the channels or flues. The layers are thus carried up to about forty-five in number, the last two being of burnt bricks, though in some kilns four layers of burnt bricks are used for closing in. The crevices are secured with brick earth or clay, on which sand is put; the door of the kiln is then closed with one or two thicknesses of burnt brick, then an interval of about 10 in. or 12 in. filled in with sand, and this secured with walling, and by a wooden strut. The object of the sand is to prevent any of the heat from escaping through the crevices.

It is to be remarked that, in laying the bricks in the kiln, as they are laid down, a cloth is put over them and under the feet of the workmen, so as to prevent any of the sand which might fall off, from getting down and blocking up the interval or interstice which naturally remains between each brick, and so interrupting the passage of the flame, and causing an unequal heat or combustion in the kiln.

The kiln being filled, a sufficient quantity of peat turf is introduced into the flues, of which one end is closed up with burnt bricks, and the turf is set fire to. The turf used is from Friesland, which is reckoned better than Holland turf, being lighter, less compact, and less earthy, composed of thicker roots and plants, burning quicker and with plenty of flame, and leaving no ash. The general time in Holland during which the supply of turf by the flues is kept up, is for about four-and-twenty hours, taking care at first to obtain a gradual heat, and supplying fresh turf about every two hours. The fireman, by practice, throws the turfs in through the small fire openings, and as far in as he judges necessary. When one side has thus been heated, the flue openings are closed, and the other ends opened for four-and-twenty hours, and supplied with fuel; and this alternate process is kept up for about three or four weeks, the time necessary to burn large bricks. In some kilns, however, the fire is kept up for five or six weeks, depending upon their size and the state of the weather. A fortnight or three weeks is, however, sometimes enough for the clinkers.

The burning having been concluded, about three weeks are allowed for cooling. It generally happens that the mass of brick sinks in in some places, arising partly from the diminution of volume produced by burning, and partly from the melting of some of the bricks which have been exposed to too great heat.

The quality of the bricks depends upon the degree of burning to which they have been subjected. Those from about a third from the middle of the top of the kiln, or near the centre, are black, very sonorous, compact and well shaped, breaking with a vitrified fracture. These are generally employed for cellars, reservoirs, and cisterns, and are most esteemed.

III.—TILES.

The tiles manufactured in Holland are flat, hollow, S shaped, or with a square opening in the middle to let in a pane of glass, being much used for lighting lofts and garrets all over the Low Countries. They are either red, grey, or blue, or glazed on one side only. The flat paving tiles are about 8½ in. square by 1 in. thick; they are used principally for cisterns and for bakers' ovens. The clay for tiles, it is to be noted, is in all cases more carefully prepared than that for bricks, being ground up wet in a pugmill or tub, with a shaft carrying half a dozen blades. By this means, roots, grass, &c., are got rid of. The clay comes out of the pugmill of the consistence of potters' clay, and is kept under a shed, where it is kneaded by women, with their hands, to the rough form of a tile, on a table dusted with sand. These pieces are carried off to the moulders, who are two in number, a rough moulder and a finisher. The tiles are then dried under sheds, and afterwards in the sun. With regard to the flat paving tiles, they are at first rough-moulded about an inch larger than the subsequent size, and a little thicker, and then laid out to dry under a shed, until such time as the thumb can hardly make an impression on them. They are then taken to a finishing-moulder, who, on a table quite level and slightly dusted with sand, lays one of the tiles, and strikes it twice or thrice with a rammer of wood larger than the tile, so as to compress it. He then takes a mould of wood, strengthened with iron and with iron cutting edges, and puts it on the tile which he cuts to the size. The mould is of course wetted each time it is used. The tiles are then regularly dried. In Switzerand and Alsace an iron mould is used.

IV.—TILE-KILNS.

The tile-kiln is generally within a building, and about 16 ft. long (in ordinary dimension), 10 ft. wide, and 10 ft. high. The walls are from 4½ ft. to 5 ft. thick, secured outside with great beams, and so secured together as to form a square frame. Some of the largest of them are pierced with four flue-holes, as in brick-kilns; but the flues are formed by a series of brick arches, about 2½ ft. wide by 16 in. high. The opening of the flue-hole is about 10 in. by 8 or 9 in. high. On their upper surface, these series of arches form a kind of grating, on which the tiles are laid. The kiln is covered in at top with a brick arch, pierced with holes of different sizes. The kilns are charged from an opening which is constructed in one of the side walls, which opening is, of course, during the burning, blocked up and well secured. The fuel used is turf, as in the brick-kilns, and the fire is kept up for forty hours together, which is considered enough for the burning. Three days are then allowed for cooling, and they are afterwards taken out of the kiln. Those tiles which are to be made of a greyish colour are thus treated. It having been ascertained that the tiles are burnt enough, and while still red hot, a quantity of small fagots of green alder with the leaves on is introduced into each flue. The flue-holes are then well secured, and the holes in the roof each stopped with a paving tile, and the whole surface is covered with 4 in. or 5 in. of sand, on which a quantity of water is thrown, to prevent the smoke from escaping anywhere. It is this smoke which gives the grey colour to the tiles, both internally and externally. The kiln is then left closed for a week, when the sand is taken off the top, the door and roof-holes are opened, as also the flue-holes, and the charcoal produced by the fagots taken out. Forty-eight hours after, the kiln is cool enough to allow of the tiles being taken out, and the kiln charged again. Whenever any of the tiles are to be glazed, they are varnished after they are baked; the glaze being put on, the tiles are put in a potter's oven till the composition begins to run. The glaze is generally made from what are called lead ashes, being lead melted and stirred with a ladle till it is reduced to ashes or dross, which is then sifted, and the refuse ground on a stone and resifted. This is mixed with pounded calcined flints. A glaze of manganese is also sometimes employed, which gives a smoke-brown colour. Iron filings produce black; copper slag, green; smalt, blue. The tile being wetted, the composition is laid on from a sieve.

The manufacture of tiles, as already observed, is principally carried on near Utrecht, in the province of Holland, which, like most of the great cities of Holland, has facilities for the transportation of its produce by water communication all over the country.

Gouda is a great seat of the pottery and tobacco-pipe manufactures, of which formerly Holland had a virtual monopoly, with regard to foreign trade, exporting largely Delft ware, Dutch porcelain, tobacco-pipes, bricks, Flanders' bricks, painted tiles, and paving tiles. The manufacture of painted tiles, for the decoration of the old fireplaces, was very extensive; and an infinite variety of designs, principally on Scripture subjects, employed many humble artists. This, however, is almost of the past. The manufacture of tobacco-pipes was another great business, suitable to the consumption of tobacco by the Netherlanders. Gouda alone had, at one time, as many as 300 establishments for the production of this article of trade. The manufacture of tobacco-pipes is still a large manufacture in England, much more considerable than is generally supposed; while manufactures of bricks and porcelain constitute a staple means of employment for many thousands of our population

A great part of these descriptions, it will be seen, strictly apply to our own practice, and are trite enough and trivial enough; but in matters of this kind, there is nothing lost by being too minute, and it is always safe. In the present case, it is worth knowing these things, for the sake of knowing that there is no difference.

CHAPTER III

BRICKMAKING AS PRACTISED AT NOTTINGHAM.

1. The mode of making bricks at Nottingham and the neighbourhood presents several peculiarities, of which the principal are:—

1st. The use of rollers for crushing the brick-earth.
2nd. The use of copper moulds.
3rd. The hacking of the bricks under cover.

2. The use of copper moulds is not confined to the immediate neighbourhood of Nottingham, but has been for some years gradually extending to other districts, and will probably, sooner or later, become general throughout the country for the manufacture of superior qualities of bricks.

3. It may be proper here to say a few words on the object of grinding the clay, so generally practised throughout Staffordshire, Derbyshire, Nottinghamshire, and Lincolnshire, and probably in many other places.

In many brickworks the earth used is not pure clay, but a very hard marl, which cannot be brought into a state of plasticity by the ordinary processes of weathering and tempering without bestowing upon it more time and labour than would be repaid by the value of the manufactured article. The expedient of grinding is, therefore, resorted to, which reduces the earth to any state of fineness required, according to the number of sets of rollers used, and the gauge to which they are worked, all hard lumps and pieces of limestone,* which would otherwise have to be picked out by hand, being crushed to powder, so as to be comparatively harmless.

4. The advantages and disadvantages of the use of rollers may be thus briefly stated,—

1st. A great deal of valuable material is used which could not be made available for brickmaking by the ordinary processes.

2nd. The process of grinding, if properly conducted, greatly assists the operations of the temperer by bringing the earth into a fine state, quite free from hard lumps.

On the other hand :

The facilities afforded by the use of rollers for working up *everything* that is not too hard to be crushed by them, induce many brickmakers to make bricks without proper regard to the nature of the material. A common practice is to work the rollers to a wide gauge, so that comparatively large pieces of limestone are suffered to pass through without being crushed by them. Where this has been the case, it need hardly be said that the bricks are worthless. They may appear sound, and may have a tolerable face, but rain and frost soon destroy them, and, in situations where they are exposed to the weather, they will become completely perished in a very few years.

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* It may be necessary to explain, that all pebbles and hard stones must be picked out by hand before grinding; where the brick earth used is much mixed with gravel, the only resource is the use of the wash mill.

5. The following description of the mode of making bricks at Nottingham will apply pretty faithfully to the practice of the brick-yards for many miles round. It will, of course, be understood that in no two yards is the manufacture carried on in exactly the same way; there being differences in the designs of the kilns, the arrangement of the buildings, and other points of detail, which may be regulated by local circumstances, or which, from the absence of any guiding principle, may be left to chance; the general features, however, are the same in all cases.

6. *Brick-earth.*—The brickmakers of Nottingham and its immediate vicinity derive their supplies of brick-earth from the strata of red marl overlying the red sandstone on which the town is built, and which in its turn rests on the coal-measures, which make their appearance at a short distance to the west of the town.

The banks of the river Trent present many good sections of these strata, as at the junction of the rivers Trent and Soar; where they are pierced by the Red Hill tunnel, on the line of the Midland Railway; and at Radcliff-on-Trent, where they form picturesque cliffs of a red colour covered with hanging wood; and they are exposed to view in many places in the immediate vicinity of Nottingham, as in the cutting for the old road over Ruddington Hill, in the Colwick cutting of the Nottingham and Lincoln Railway, and Goose Wong Road, leading to Mapperly Plains.

The marl abounds with loose and thin layers of *skerry*, or impure limestone, and in many places contains veins of gypsum, or, as it is called, *plaster stone*, which are extensively worked near Newark, and other places, for the manufacture of plaster of Paris.

The water from the wells dug in these strata is strongly impregnated with lime.

7. The colour of the bricks made at Nottingham and in the neighbourhood is very various. For making red bricks the clay is selected with care, and particular beds only are used. For common bricks the earth is taken as it comes, and the colour is very irregular and unsatisfactory, varying from a dull red to a dirty straw colour. Some of the marl burns of a creamy white tint, and has been lately used with much success in making ornamental copings and other white ware.

8. In the manufacture of common bricks no care is taken in the selection of the clay, and it is worked up as it comes to hand indiscriminately, the great object of the manufacturer being to clear his yard; the same price being paid for all clay used, whatever its quality.

Stones and pebbles are picked out by hand, but the pieces of limestone are generally left to be crushed by the rollers, and much bad material is worked up in this way which could not be made use of if the tempering were effected by treading and spade labour only.

There are, however, many beds which are sufficiently free from limestone not to require grinding, and when these are worked the rollers are not used.

9. For front bricks, and the superior qualities, the clay is selected with more or less care, receives more preparation previous to grinding, is ground finer, and is sometimes left to mellow in cellars for a considerable time before using.

10. For making rubbers for gauged arches, the clay is carefully picked, and run through a wash-mill into

pits, where it remains until by evaporation and settlement it has attained a proper degree of consistency. The clay for this purpose is generally mixed with a certain quantity of sand to diminish the labour of rubbing the bricks to gauge, the proportion varying according to the quality of the clay. The sand used for this purpose is the common rock sand, which burns of a red colour.

11. The clay immediately near the town of Nottingham is not well suited for making roofing tiles, the ware produced from it being generally very porous. This statement, however, is not to be taken without exceptions, as there is plenty of suitable clay for the purpose within a few miles' distance.

12. The old houses in Nottingham are built with very thin bricks, much of the old brickwork gauging 10½ in. to 4 courses in height, including mortar joints. These bricks are of a dark red colour, and were from works that have been long since abandoned. The bricks now made are much thicker, the walls of many new buildings gauging 21 in. to 7 courses in height, or about 13⅛ in. to 4 courses in height, including mortar joints. The common bricks are of a very uneven colour, which arises partly from the manner in which they are set in the kiln, and partly from the want of care in selecting the clay, and the quantity of limestone ground up with it. From this circumstance the fronts of many of the new buildings have a mottled appearance, which is extremely unsightly.

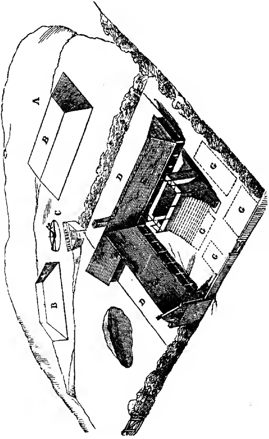
GENERAL ARRANGEMENT OF A BRICKWORK.

13. The brick-yards from which the town of Nottingham is at present supplied are situated on the slopes of a small valley along which runs the public

road from Nottingham to Southwell, and, being situated on the sides of the hills, great facilities exist for draining the workings and for bringing the ground into cultivation again after the clay has been exhausted.

14. The proprietor of a brickwork usually rents the required land from the owner of the soil, at a price per acre, and in addition to the rent pays for all clay dug, whatever its quality, at a set price per thousand bricks made and sold, exclusive of those used for the erection and repairs of the buildings and works.

Fig. 1.*



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* A more particular description of the engravings will be found at pages 92—94.

15. The arrangement of the several buildings varies with each yard more or less; but the principle on which they are laid out is the same in all cases, viz., to advance towards the kiln at each process, so as to avoid all unnecessary labour. This will be understood by inspection of fig. 1, which, it must be understood, is not an exact representation of a particular brickwork, but a diagram to explain the principle of arrangement usually followed. The pits from which the clay is dug are at the rear of the works, and at some little distance from them is placed the clay-mill, which, to save labour in wheeling the clay, is shifted from time to time as the workings recede from the kiln by the exhaustion of the clay. This is, however, not always done, as, where the mill has been fixed in a substantial manner, the saving in labour would not repay the cost of re-erection.

The hovel or drying shed generally forms two sides of a rectangular yard adjoining the public road, the kiln being placed as close to the hovel as practicable, and the working floors or flats in the rear of the latter. By this concentration of plan, the distance to which the bricks have to be carried between the successive processes of moulding, drying, hacking and burning is reduced to a minimum, which is an important point to be attended to, as the raw bricks are shifted by hand and not barrowed.

As it is not always possible to obtain a supply of water at those parts of the works where it is wanted to be used, a water-cart* is kept at some yards for this purpose, the supply being taken from a pond into which the drainage of the works is conducted.

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* The water-cart is seldom used, except where the water has to be fetched a considerable distance—indeed rarely, but in times of drought. It is usually carried, in the yard, in buckets with yokes, as in the time of Pharaoh.

The goods for sale are stacked in the open part of the yard as near the public road as practicable.

16. *Clay-Mill.*—The machinery used in grinding the clay is very simple. The clay-mill consists of one or more pairs of cast-iron rollers, set very close together in a horizontal position, and driven by a horse who walks in a circular track, and, by means of the beam to which he is attached, puts in motion a horizontal bevelled driving-wheel placed at the centre of the horse track. A horizontal shaft connected at one end with one of the rollers by a universal joint, and having a bevelled pinion at the other end, communicates the motion of the driving-wheel to the rollers by spur-wheels keyed on their axles. The clay is tipped in a wooden hopper placed over the rollers, and passing slowly between the latter falls on a floor about 8 feet below them, where it is tempered for the moulder.

17. The common clay-mill has only one set of rollers, but the addition of a second set is a great improvement. In this case the bottom rollers are placed almost in contact with each other, and should be faced in the lathe to make them perfectly true. If only one set be used this is a useless expense, as the gauge to which they are worked is too wide for any advantage to be derived from it.

18. Figures 2, 3, 4 represent a one-horse mill with a single pair of rollers 18 in. in diameter, and 30 in. long, manufactured by Messrs. Clayton and Shuttleworth, of Lincoln, who kindly furnished the drawings from which the engravings have been made. The detailed description of the several parts will be found in art. 69.

Fig. 2

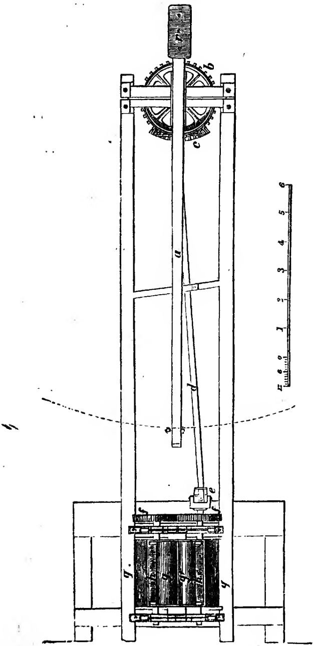


Fig. 3.

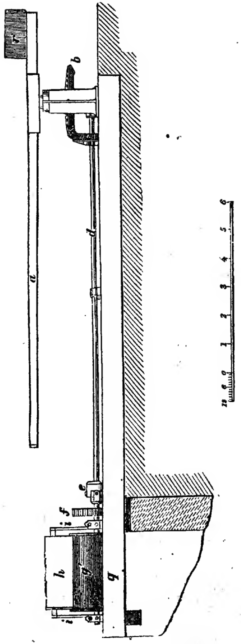
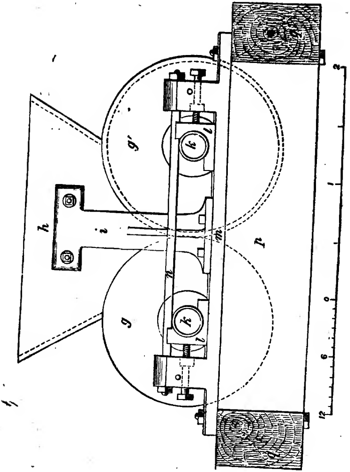


Fig. 4.



This is a very good mill, of simple construction, and not expensive, the cost when ready for fixing (exclusive of foundations and brickwork) being £50.

It cannot be too strongly insisted upon that the machinery should be boxed up close, so as to prevent stones or clay from clogging the wheels, as where this is not done the machinery will unavoidably become deranged in a very short time.

19. In many yards, the horse-track is raised to the level of the top of the hopper, so that none of the machinery is exposed. A very good arrangement of this kind is shown in fig. 5, of which a detailed description is given in art. 69.

20. The quantity of work performed will of course vary greatly, according to the distance between the rollers and the consequent fineness to which the clay is ground. One mill will grind sufficient clay to keep six moulders fully employed, and therefore there are very few yards in which the rollers are constantly in work.

21. The length of time during which a clay-mill will last in good working condition is chiefly regulated by the wear of the rollers. If the iron is of very uniform quality, and care be taken to pick out all the pebbles from the clay, a pair of rollers will last many years. The other parts of the machinery will last with care for an indefinite length of time.

22. *Wash-mill.*—The wash-mill is used only in the manufacture of arch bricks, and does not differ from that used in other places. The only one visited by the author consists of a circular trough, lined with brickwork, in which the clay is cut and stirred up with upright knives fastened to a horse-beam. From this trough, the slip runs through a grating into a brick tank, where it remains until by evaporation and settlement it becomes sufficiently consolidated for use.

23. *The Pug-mill* is not used in the Nottingham* brick-yards; the tempering of the clay, after grinding, being effected by treading and spade labour. Instead of the clay being tempered directly after grinding, it is

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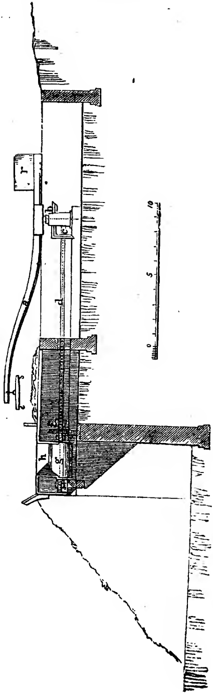
* It is, however, used in the neighbourhood.

Fig. 5.

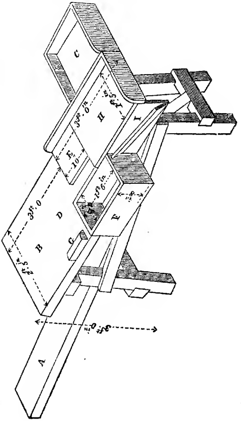


sometimes deposited to ripen in damp cellars for a year or more. This is done for the best bricks only.

24. *The Moulding Sand* used is the common rock sand, which burns of a red colour. In making white bricks this is a great disadvantage, as it causes red streaks, which greatly injure their colour. The sand is only used to sprinkle upon the table to prevent the clay from adhering thereto, and therefore sand with a sharp grit is preferred.

25. *The Moulding Table* is shown in fig. 6. It is

Fig. 6.



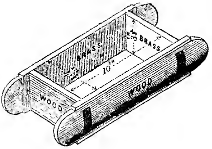
furnished with a sand-box, which is sometimes fixed to the table, as shown in the cut, and sometimes detached, and with a water-box, in which the moulder dips his hands every time he moulds a brick. In the operation of moulding, the moulder stands in front of the table, with the water-box immediately in front of him, the tempered clay at his right hand, and the sand-box at his left. A sloping plank is placed at one end of the table to enable the boy who brings the clay from the temperer to deposit it more conveniently on the table. The boy who takes off the newly-made bricks, and brings back the empty mould, stands on the side of the table opposite the moulder, to the right of the water-box, in which he washes his hands after each journey, to prevent the clay from drying on them.

The cost of a moulding table varies according to the care with which it is made. Such a one as shown in the cut will cost about 20*s.*, and will last, with occasional repairs, for several years. The part where the brick is moulded soon becomes worn, and has to be cased as shown in the cut. This casing extends over the part where the brick is taken off by the carrier boy; but, as the wear is not uniform over this space, the casing is in two or more pieces, the part where the brick is moulded wearing much faster than the others, and requiring renewal sooner.

It is of importance that the drippings from the table should not fall on the drying floor, as they would render it slippery and unfit for use; a rim is therefore placed at one end, and along a part of one side of the table, and the opposite side is furnished with a kind of apron and gutter, by means of which the slush is conducted to a tub placed under one corner of the table, but which is not shown in the cut.

26. *Brick Moulds.*—Until lately the moulds used were made of wood, but these have been almost entirely superseded by brass, or, as they are technically called, copper, moulds.

Fig. 7.



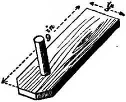
There are several different ways in which these moulds are made. Sometimes the brass work is merely an inside lining, screwed to a wooden mould; but the best construction appears to be that shown in fig. 7, in which the mould is of brass, cast in four pieces, and riveted together at the angles, the woodwork being in four distinct pieces and attached to the brass mould by the angle rivets. These moulds are costly, and formerly a pair of moulds cost £2, but they may now be had for £1 5*s.* the pair.

It will be seen, by reference to the engraving, that the brass overlaps the woodwork all round the mould on each side, and these portions of the mould wear away very rapidly, so that the bricks made at the close of the season are considerably thinner than those made at its commencement. This renders it necessary to renew the projecting rims from time to time as they become worn down with use, and this will require to be done every season if the mould has been in constant use. It is an expensive operation, as the new rim has to be brazed on to the old part, and this must be done with great nicety, and so as to make a perfectly flush joint on the inside of the mould, or the latter would be rendered useless. The cost of *plating* a pair of moulds is nearly the same as their original cost, 20*s*. being charged for the operation, and therefore it would be preferable to use the moulds until they are quite worn out, and then to replace them with new ones.

27. The use of copper moulds is confined to the making of building bricks, and quarries for paving floors, their weight and great cost preventing their employment for larger articles.

28. The mould has no bottom as in the London practice, nor is it placed upon a raised moulding board as in Staffordshire; but rests on the moulding table itself, the top and bottom beds of the brick being formed at two distinct operations with a little instrument called a plane.

Fig. 8.



29. *The Plane*, fig. 8, is usually made 9 in. long by 3 in. broad, with a handle at one end. Its use is to compress the clay in the mould, and to work over the top and bottom beds of the brick to give them an even surface.

The strike is not used at Nottingham.

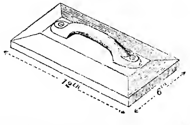
30. *The Flats*, or working floors, are prepared with care, by levelling and rolling, so as to make them hard and even, and are laid out with a slight fall, so that no water may lodge on them. They are well sanded, and constant care is requisite to keep them free from weeds. Their usual width is about 10 yards. In unfavourable weather a single moulder will sometimes have as many as 7,000 bricks on the flats at once, for which an area of from 300 to 400 superficial yards will be required. This, however, is an extreme case, and in good drying weather a moulder does not require more than half that extent of floor, or even less than this.

31. *The Hovel*, or drying shed, in which the bricks are hacked, is generally built in the roughest and cheapest manner possible, with open sides and a tiled roof, supported by wooden posts or brick piers; the width of the hovel is about 18 ft., or rather more than the length of a hack, but the eaves are made to project a couple of feet or so beyond this distance, in order to give additional shelter from the rain, for which reason, as well as for the sake of economy, the eaves are carried down so low as to make it necessary to stoop to enter the shed.

Some of the hovels have flues under the floor, the fire-places being placed in a pit sunk at one end of the hovel, and the chimney at the opposite end. These flues are made use of when the demand for bricks is so great that sufficient time cannot be allowed for drying in the open air, and also during inclement seasons. The sides of the hovel are then walled up with loose brickwork to retain the heat. No specific rule can be given for the relative sizes of the hovel and the drying floor. The common practice appears to be to make them of the same length, which allows ample room, and enables the moulder to keep a portion of his shed always available as a drying floor when the weather is too wet to allow of the bricks being laid out on the flats. When this is the case the moulder protects the raw bricks from drafts, by surrounding them with a skirting, so to speak, of planks. This is a very necessary precaution, for the currents of air from different parts of the shed would cause the bricks to dry unequally, and they would crack and become unsound. Matting is frequently hung up at the sides of the hovel for this purpose, and is also much used in some yards to prevent the finer clays, when tempered, from drying too rapidly where cellars are not provided for that purpose.

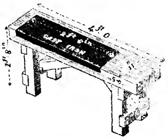
32. The above description applies to the ordinary hovel, but the best front bricks are dried wholly under cover in a brick hovel inclosed by walls on all sides, and furnished with flues, by which the place is kept at a regular temperature. The expense, however, of conducting the whole of the drying under cover in this manner is too great to allow of its general adoption.

Fig. 9.



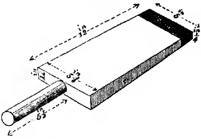
33. *The clapper*, fig. 9, is simply a piece of board 12 in. by 6 in. with a handle on one side. It is used to flatten the surfaces of the bricks as they lie on the floors, and the bricks are also beaten with it during the process of hacking, to correct any warping which may have taken place in the first stage of drying.

Fig. 10.



34. *Dressing Bench.*—Fig. 10. This is simply a stout bench, to which is fitted a plate of cast-iron, on which the best front bricks are rubbed or *polished*, to make them perfectly true and even; the workman, at the same time, beating them with a wedge-shaped beater, tipped with iron, called a *dresser*, fig. 11. This operation toughens the brick, corrects any warping which may have taken place, and leaves the arrises very sharp.

Fig. 11.



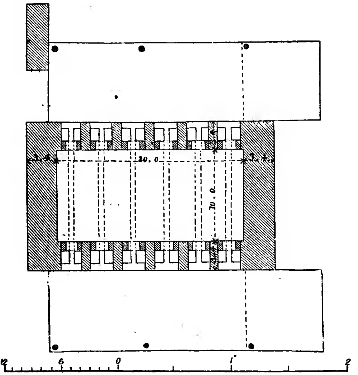
35. *Machinery for pressing Bricks.* — In some yards screw presses are used for pressing front bricks, and with considerable success. It is, however, questionable whether they are as durable as those dressed by hand. In making machinery for this purpose the great desiderata are, 1st, to make the metal mould in which the brick is compressed so strong that it shall not spring on the application of the power; and, 2nd, that the piston shall exactly fit the mould: when, from bad workmanship or long use, this is not the case, the clay is forced between the piston and the mould for a short distance, leaving a slightly-raised edge all round the side of the brick.

36. We do not propose here to enter upon a comparison of the respective merits of machine-pressed bricks and those dressed by hand. The operation of dressing on the bench requires an experienced workman, whilst a common labourer can use a machine. For this reason machine-pressed bricks can be produced much cheaper than those dressed by hand, and there is little inducement to employ the latter process.

37. *Kiln.*—The kilns vary considerably as regards their dimensions and constructive details, but they are all built on the same principle.

The kiln shown in figs. 12, 13, 14, 15, 16, and 17, is a good one, though rather weak at the angles, and will convey an idea of the general construction. (See chap. ix., page 210.)

Fig. 12.



It consists of four upright walls, inclosing a rectangular chamber. The floor is sunk about 4 ft. below the general surface of the ground, and is not paved. The doorways for setting and drawing the kiln are merely narrow openings at the ends of the kiln, raised a step above the ground, and about 5 ft. from the floor. The fire-holes are arched openings opposite each other on the sides of the kiln, lined with fire bricks, which require to be renewed from time to time, generally every season. The width of these holes is reduced to the required space by temporary piers of brickwork, so as to leave a narrow opening about 8 in. wide and about 3 ft. high. This will be understood by reference to fig. 12, in which

Fig. 13.

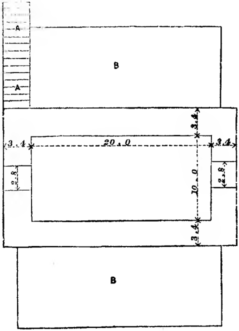


Fig. 14.

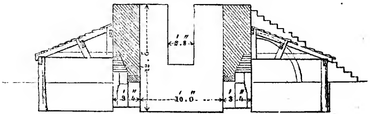


Fig. 15.

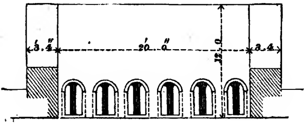


Fig. 16.

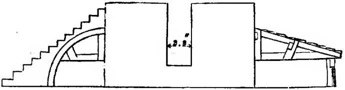
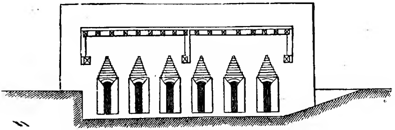


Fig. 17.



the dark shading shows the fire-brick lining, and the unshaded parts the temporary piers.

On each side of the kiln a pit is sunk to the level of the floor, and covered with a lean-to roof, which protects the fuel and the fire-man from the weather, and prevents the wind from setting against the fires. The walls of the kiln are about 3 ft. thick, and are built of old bricks, rubble stone, and the refuse of the yard. No mortar is used, as the use of lime would destroy the brickwork, under the intense heat to which the walls are exposed. The bricks are therefore set in loam or fire-clay, if it can be readily procured. The fire-bricks for lining the fire-holes are sometimes brought from Ilkeston, where excellent fire-clay is worked, but it is most common to make them at the yards with such clay as can be got in the neighbourhood, which answers pretty well. This clay is brought from the neighbouring collieries, and is obtained when sinking shafts; there is no fire-clay at any of the Nottingham yards.

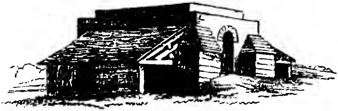
38. Instead of being built with walls of parallel thickness, resting on arches, as in the example just described, some kilns are built with walls of great thickness at bottom, and diminishing by set-offs until, near the top of the kiln, they are comparatively thin. Many kilns also are provided with massive buttresses at the angles, with the intention of counteracting the tendency which the walls have to lift themselves with the heat.

Very great care is requisite in drying a newly-built kiln, or the walls will be cracked at the first firing, and the thicker the walls the greater the care necessary.

39. So long as the brickwork is sufficiently thick to retain the heat, no purpose is attained by increasing the strength of the walls, unless they are made so massive that they are unaffected by the heat externally, and heavy enough to counteract the *lifting* cause by the expansion of the sides exposed to the fire. In the one case the walls expand bodily with the heat, forming large and dangerous cracks; in the other, separation takes place between the inside and outside of the walls, from the expansion of the parts most exposed to the heat, and the kiln soon requires relining.

40. The kiln shown in figs. 12 to 17 is an example

Fig. 18.



of the mode of building with walls of the same thickness top and bottom; that shown in fig. 18 is one of a more massive construction, and has buttresses at the angles. The upper part of this kiln is formed by building, in a temporary manner, a thin parapet round the inside of the top of the walls, about a couple of feet in height. This expedient is often resorted to for the sake of increasing the capacity of a kiln at a small expense.

41. Some of the kilns are provided with a flight of steps by which access is obtained to the top, in others ladders are used for this purpose. Many of the kilns have also a kind of light fence round the top, made of rough poles. This serves as a protection from falling, and as a scaffold to which screens may be hung in windy weather to keep the wind from setting on the top of the kiln. This fence is shown in fig. 2. The outside staircase is shown in figs. 1, 13, and 16.

42. The sizes of the kilns vary considerably. A kiln such as that shown in figs. 12 to 17, 20 ft. long, 10 wide, and 12 ft. high, will, with the addition of a parapet, burn 25,000 bricks at once, and will require rather more than that number of bricks for its erection. The cost of such a kiln would be from £20 to £30, the value of the materials being almost nominal.

The capacity of a kiln may be roughly calculated on the assumption that ten bricks require a cubic foot of space in the kiln, but much, of course, will depend on the nature of the clay and the amount of shrinkage before burning.

43. A well-built kiln will last for many years with occasional repairs.

PROCESS OF BRICKMAKING.

44. *Clay digging.*—The clay or marl is, or should be, dug in the autumn, and collected in large heaps at the bottom of the slopes, to be mellowed by the winter frosts. These heaps are shown in fig. 1.

The cost of this operation varies from 1*s.* to 1*s.* 9*d.* per 1,000 bricks, according to the labour of getting the clay, and the distance to which it has to be wheeled.

45. *Tempering.*—In the spring the clay is turned over by spade labour, being at the same time well watered and trodden. The pebbles and large lumps of limestone are picked out by hand with more or less care. The prepared clay is then wheeled to the mill, and tipped into the hopper. Sometimes the clay, after being ground, is at once tempered for use on the floor beneath the rollers; but for the best bricks, as before stated, it is allowed to remain in cellars to ripen for a year or more.

46. The temperer is generally paid by the moulder, who contracts for tempering, moulding, and hacking at a price per 1,000. The cost of tempering for common bricks is about 1*s.* 3*d.*, exclusive of the cost of horsing the mill, which is borne by the proprietor of the yard.

One temperer will keep one moulding-table constantly supplied, and will also assist the moulder in getting up his bricks from the floor.

47. *Moulding.*—A sufficient quantity of clay having been prepared on the tempering floor, one of the moulder's boys takes up as large a lump as he can

conveniently carry, and, placing it on his head, walks with it to the moulding table, and walking up the sloping plank, deposits it at the end of the table, to the right hand of the moulder at B, fig. 6.

The moulder having sprinkled some dry sand over the part of the table marked D, takes from the heap of tempered clay a piece sufficient to make a brick, and kneads this clot with his hands on the sanded part of the table, so as to bring it approximately into shape. He then raises the clot in the air, and dashes it with some force into the mould, striking off the superfluous clay with his fingers. He then dips his hands into the water-box, and, with very wet hands, works over the face of the brick, so as to force the clay perfectly into the mould in every part. He next takes the plane and passes it backwards and forwards with considerable pressure, until the face of the brick is flush with the edges of the mould, and then, reversing the mould, planes the underside in the same way. The brick being moulded, the moulder slides it on the wet table to his left hand side, where it is taken off by a second boy, who carries it, mould and all, to an unoccupied part of the floor, where he turns it out carefully on one of its sides, and returns with the empty mould. Meanwhile the moulder has made another brick in a second mould, which is now ready to be taken off, and this process is repeated until the distance to an unoccupied part of the floor is too great to allow of the boys returning in time, and the table is then shifted to another part of the floor.

48. *Drying.*—After the bricks have remained for a few hours in the position in which they were first placed on the floors, they are turned on their edges by a boy, who turns up two at once, one with each hand. They

remain in this position a few hours longer, and are then laid flat on the opposite side to that on which they were first placed. Careful moulders sprinkle sand over the wet bricks as they lie on the floor, which absorbs the superabundant moisture, and renders them less liable to crack; but this is not always done.

The new bricks sometimes also undergo a slight dressing with the clapper, to take off any roughness at the edges, and to correct any alteration of form which may have taken place on turning them out of the mould, and in some cases they are scraped with a small iron scraper, to remove any dirt that may adhere to them.

After lying flat a few hours longer, they are carried by the boys, three at a time, to the hovel, where the moulder builds them into hacks 50 bricks long and 14 courses high, each hack containing 700 bricks. As the bricks are hacked they are *batted* with the clapper, to correct any warping which may have taken place whilst lying on the floors. The bricks remain in the hovel without being again shifted, until they are ready for burning.

49. The time allowed for drying varies with the weather, the size of the kiln, and the demand for bricks. Some brickmakers get the bricks out of the kiln within a fortnight of their leaving the moulds, but this haste is very prejudicial to the soundness of the bricks, and, as a general rule, three weeks is the least time that should be allowed for drying.

The time that the raw bricks lie on the flats depends solely on the weather. In good drying weather the bricks are made one day and hacked the next; but at other times several days may elapse before they are fit for hacking.

50. It is not very easy to separate the cost of hacking

from that of moulding, as both operations are performed by the moulder. The price for moulding, including tempering and hacking, is from 4*s.* 6*d.* per 1,000, and upwards; 4*s.* 9*d.* is a common price. Where the clay is ground the moulder pays for feeding the mill, but not for horsing it, this expense being borne by the proprietor of the yard.

51. The above description refers to the ordinary mode of proceeding, but for facing-bricks additional processes are employed. *Pressed bricks,* as their name implies, are prepared by putting the raw bricks one at a time, when nearly dry, into a metal mould, in which they are forcibly compressed by the action of a powerful lever which forces up the piston forming the bottom of the mould. This gives a very beautiful face to the brick, and leaves the arrises very sharp, but bricks so prepared require longer time for drying and judicious management in the kiln, otherwise they will be unsound, and when exposed to the weather soon become perished.

52. *Polished bricks,* as they are called, are rubbed upon a bench plated with iron, to make their surfaces perfectly even, and are also dressed with a dresser, as before described. This process is only gone through with the very best bricks, and its cost is such that it is not employed to any very great extent.

53. The contraction of the clay in drying is very slight, and no perceptible diminution of size takes place in burning if the bricks have been previously thoroughly dried.

The brick moulds are made of different sizes at different yards, their proportions having been altered from time to time, so as to increase the depths of the moulds at the expense of the other dimensions.

When the thickness of a piece of brickwork is measured by the number of bricks, as in house building, and not by feet and inches, as in building the piers of bridges and other solid works, the number of bricks required for the execution of a rod of brickwork is considerably reduced by a very trifling addition to the thickness of the bricks, and this is always an inducement to purchasers to prefer the yards where the deepest moulds are used.

The largest common bricks now made measure, when burnt, $9\frac{1}{2}$ in. long, $4\frac{5}{8}$ in. wide, and $3\frac{1}{16}$ in. thick, or thereabouts; the size of the moulds being $9\frac{7}{8}$ in. long by $4\frac{13}{16}$ in. wide, and $3\frac{3}{6}$ in. deep. These bricks weigh about 7 lbs. 15 oz. when burnt.

The best red facing-bricks made at Mr. Wood's yard, in the Carlton Road, measure, when burnt, $9\frac{1}{8}$ in. long, $4\frac{1}{2}$ in. wide, and $2\frac{13}{16}$ in. thick. The moulds for these bricks are 10 in. long, $4\frac{7}{8}$ in. wide, and $3\frac{1}{8}$ in. deep.

54. A good moulder, if solely occupied in moulding, will turn out 2,000 bricks in a day, between 6 A.M. and 6 P.M.; but as nearly one-third of the moulder's time is taken up with hacking, the average day's work is not more than about 1,300 per day, or between 7,000 and 8,000 weekly.

55. *Burning.*—The setting of the kiln is an operation on which much depends, and requires to be done by an experienced hand, as there is a great deal of art in arranging the bricks in a proper manner, so as to allow the heat to be diffused equally through the kiln, and to afford a proper draught, so as to obtain the greatest amount of steady heat with the smallest expenditure of fuel.

The lower part of the kiln is filled with common bricks, narrow openings being left, as shown by the dotted lines in fig. 12, forming flues connecting the opposite fire-holes, the tops of these flues being formed by oversetting the bricks on each side till they meet. These flues are of the same height as the fire-holes.

The best bricks* are placed in the middle of the kiln, and above these again are placed common bricks up to the top. The bricks are not placed close together, but a space is left all round each brick to allow of the passage of the heat round it; the bricks in the successive courses being crossed either slantwise, or at right angles to each other. When a brick rests partly on others, and is partly exposed to the fire, the exposed part will commonly be found of a lighter red than those to which the fire has had no access, and this is one great cause of the mottled colour of the Nottingham bricks. When, therefore, it is wished to produce bricks of a uniform red tint, great care is taken to keep the faces and ends of the bricks in close contact, crossing them every few courses only.

The kiln being topped, the doorways are built up with refuse brick and plastered over with clay, to prevent the admission of currents of cold air, and the fires being lighted, the heat is got up gradually, care being taken not to urge the fires, until all the steam is driven off from the bricks, and the actual burning begins. When the fire has attained its full heat, the fire-holes are partially stopped with clay, and the top of the kiln is covered over with earth, turfs, or boards, to check the draught, and a steady uniform heat is kept up until the completion of the burning, which generally occupies three days and three nights from the first lighting of the fires; at the expiration of which time the fire-holes are completely stopped, and the fires put out; after the fires have been extinguished, the kiln should be allowed to cool very gradually, as the soundness of the bricks is much deteriorated by the kiln being opened too soon; this, however, is a point not sufficiently attended to.

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* If tiles be burnt at the same time, which is frequently the case, as they cannot be burnt alone without great waste, they take the same position in the kiln as dressed bricks.

56. The fuel employed is coal,* the quantity† used being about half a ton per 1,000 bricks, the exact amount depending on the quality of the fuel and the judicious setting of the kiln. The town of Nottingham being situated on the very edge of the Nottinghamshire coal-field, the cost of firing is very low, and excellent coal can be laid down at the yards at from 8*s*. 6*d*. per ton upwards. The small coal or *slack* frequently used in the early stage of burning does not cost more than 5*s*. to 6*s*. per ton.

57. The colour and soundness of the bricks vary according to their position in the kiln and the intensity of the heat to which they have been exposed. Those nearest the fire become partially vitrified, and of a blackish tint. Those which have been more favourably placed burn of various tints according to the nature of the clay, from red to straw colour and white, and when struck together ring with a clear metallic sound. Those which are underburnt are tender, of a pale red colour, and give a dull sound when struck together.

58. The cost of setting and drawing the kiln is generally reckoned at 1*s*. 6*d*. per 1,000, this including stacking the bricks in the yard, or placing them in the carts of the purchasers. If, however, they are

---

* Soft coal is preferred.

† In some great yards a deal of coal is wasted on the top of the kiln. As the heat has always an upward tendency, this has very little effect on the bricks, and a great deal of fuel is wasted in smoke and flame.

not for immediate sale, an additional 6*d.* is charged for loading the carts.

59. The labour in firing is reckoned at 1*s.* per 1,000.

60. At Nottingham, and at the yards in the neighbourhood, many varieties of brick are manufactured; as cant, or splayed bricks, for plinths; weathered and throated copings of several sizes; round copings; bricks with quarter-round ends; wedge-shaped bricks for culverts; compass, or curved bricks for lining shafts and wells, and also paving, roofing, and draining tiles of all descriptions. It is unnecessary to enter into any details on the manufacture of these articles, as they offer no particular points of interest. It may, however, be worth while to mention that the use of copper moulds is confined to the manufacture of those articles which are of a convenient size, and for which there is a large demand; the moulds for cant bricks, compass bricks, and other fancy articles for which there is only a limited demand, being made of wood.

COST OF MANUFACTURE.

61. *Land, and Brick-earth.*—The proprietor of a brickwork usually rents the necessary land at a price per acre, and in addition pays for all clay removed at a set price, whatever its quality.

As the brick-earth is exhausted, or the workings reach an inconvenient depth, the ground is levelled and again thrown into cultivation. This is of course done at the earliest period possible; and in some cases the rental of the land is nearly made up by the profit derived from cultivating the site of the exhausted workings, so that it is impossible to give an accurate estimate of the proportion which the rental of the land bears to the total cost of manufacture, as it must vary widely in each particular case. This remark does not hold good with regard to the brick-earth, which is paid for at the rate of 8*d*. per cubic yard, or 2*s*. per 1,000 bricks, a thousand bricks requiring about 3 cubic yards of clay.

It must be remembered that, as above stated, this price is paid for all clay removed, whether suitable or not for brickmaking. For common bricks the earth is taken as it comes, good and bad being ground up together; the cost of grinding being less than the loss which would result from the rejection of the inferior earths, which are often so hard, and contain so much skerry in pieces of all sizes from that of a walnut to that of a man's head, that they could not be worked up by the ordinary process of tempering by treading and spade labour only. For front bricks and the best qualities, the clay is carefully picked, and the cost is proportionately increased thereby.

No estimate can be given for the amount of land required for making a given number of bricks, as it depends on the situation of the yard and the depth to which the workings can be carried.

62. *Buildings and Machinery*.—From the circumstance that in existing yards the buildings have been erected at different times without any very systematic plan, it is not very easy to ascertain what are the best relative sizes of working floors, hovels and kilns, or what extent of building and plant are required for working a yard to the greatest advantage. Unless the manufacture be conducted on a very large scale, the grinding-mill will, in most cases, be often unemployed; and the wash-mill being used only in the manufacture of arch bricks, it is only in the immediate neighbour-

hood of a large town that a return for the cost of its erection can be hoped for. It will always be found an advantage to have an excess of shed-room rather than the contrary.

63. The following rough estimate will give an idea of the buildings and machinery required for mounting a new yard, to produce from 40,000 to 50,000 per week:—

1 clay-mill.
120 yards lineal of hovel, 6 yards wide.
1,200 yards superficial of working floor.

This extent of hovel and floor will be sufficient for the operations of six moulders; and, taking the work of each moulder to average throughout the season 1,300 per diem, the week's work of the six moulders would produce 46,800 per week, or in round numbers 140,000 every three weeks.

This rate of production would render necessary two kilns, each to burn 35,000, and these kilns would be kept in constant activity, each kiln being fired twice every three weeks.

64. For a yard in which it is proposed to make all kinds of brick ware additional buildings will be required, as:—

Cellars for ripening the ground clay;
A tempering shed, for tempering under cover;
One or more drying-houses, provided with furnaces and flues;
A wash-mill for running the clay for making rubbers.

Besides the above erections, there will be required in all yards stabling to a greater or less extent; a cottage for the under-taker of the yard; and sheds and outbuildings for keeping tools, carts, and implements.

65. *Tools.* — The tools required by each moulder are :—

A pair of brass moulds;
A moulding table, and appurtenances complete;
A plane;
A clapper.

In addition to these implements a variety of other articles are required, as shovels, picks, barrows, planks, sand baskets, sieves, &c., which are kept in store by the proprietor of the yard, and supplied to the men as required.

66. *Labour.*—The proprietor of the yard finds all tools and implements, sand, and coals, and horses the mills. The general management of the yard is conducted by an under-taker, who superintends the yard and contracts with the proprietor for all the labour required in the actual manufacture, at a price per 1,000 on the tale of bricks delivered from the kiln, the under-taker bearing all loss from frost, wet, or other causes.

The under-taker sublets the moulding to a moulder, who contracts with him at a price per 1,000 to mould and hack the bricks ready for setting in the kiln; the moulder employing two boys to assist him in moulding and hacking, and also a temperer, who tempers the clay for him, and assists in getting up the bricks from the floor. The first turning over of the clay is performed by labourers, under the direction of the under-taker, who, with the assistance of a few boys and labourers, sets and draws the kilns himself, and attends to the burning.

67. The actual selling price of bricks is regulated more by the demand and the amount of competition

than by the cost of their production. Good building bricks, made in copper moulds, may be had in Nottingham at 25*s.* per 1,000; but a fair selling price may be considered as 28*s.* per 1,000, which may be thus subdivided :—

		£	*s.*	*d.*
Clay digging	per 1,000	0	1	6
Turning over and watering clay and feeding mill	,,	0	0	8
Grinding	,,	0	0	6
Tempering for moulder	,,	0	0	4
Moulding, drying and hacking	,,	0	4	0
Setting and drawing kiln	,,	0	1	6
Burning	,,	0	1	6
Total cost of labour	,,	0	10	0
Coal, half a ton, at 10*s.*	,,	0	5	0
Clay	,,	0	2	0
Rent, tools, machinery, and profit	,,	0	11	0
Selling price at yard	,,	1	8	0

This may be considered as the lowest price which will afford any profit to the proprietor of the yard, when proper allowance is made for depreciation in buildings and machinery, tools, repairs, and other contingencies.

68. The relative value of the different qualities of brick may be thus stated :—

		£	*s.*	*d.*
Common bricks (the clay not picked)	per 1,000	1	8	0
Front bricks (made in copper moulds, the clay picked)	,,	1	13	0
Polished bricks (made in copper moulds, the earth selected with care, and the bricks dressed on a bench)	,,	3	0	0

69. REFERENCE TO THE ILLUSTRATIONS ACCOMPANYING THE FOREGOING ACCOUNT OF BRICKMAKING AS PRACTISED IN NOTTINGHAM.

Fig. 1. General view of a brickwork, showing the arrangement of the works.

- A. The face of the workings.
- B B. Heaps of brick-earth, dug in the autumn, to be worked up the following season, after being mellowed by the winter frosts.
- C. The clay-mill.
- D D. The working floors, generally made about 9 or 10 yards wide.
- E. The hovel. This hovel is flued,—the door at the end of the hovel next the road is the entrance to the furnace pit; the chimney into which the flues are conducted is shown at the opposite end. In some drying houses the flues are made to return nearly to the furnaces before they are led into the chimney, so that the latter is close to the former.
- F. The kiln. This form of kiln is a weak one, and is liable to be split from top to bottom by the expansion of the walls, from the intense heat to which they are exposed. The reader will observe the steps and the wooden fence round the top of the walls, mentioned in article 41.
- G. Goods for sale.

This illustration is not an exact representation of any particular brickwork, but has been made up from the details of several yards, to show the principle on which they are laid out; which is, to save all unnecessary carriage of either brick-earth or bricks, from the time of first turning over the clay to the stacking of the finished bricks in the sale yard.

Figs. 2, 3, and 4. Clay-mill, with a single pair of rollers 18 in. in diameter, and 32 in. long, as manufactured by Messrs. Clayton and Shuttleworth, of Lincoln. The letters of reference are the same in each figure.

- *a*. Horse beam, 12 feet long, from centre of horse track to centre of driving wheel.
- *b*. Bevelled driving wheel.
- *c*. Pinion.
- *d*. Driving shaft, 1½ in. diameter.
- *e*. Universal joint.
- *f f*. Spur wheels.
- *g g′*. Cast-iron rollers 18 in. diameter and 32 in. long. The roller marked *g′* is longer than the other, having a flange round each end by which the roller *g* is kept in its proper position. The roller marked *g′* is connected by the universal joint *e* with the driving shaft *d*.
- *h*. Wooden hopper.
- *i i*. Cast-iron standards to support the hopper.
- *k k*. Axles of rollers.

l l. Bearings for the axles *k k.* These bearings are made to slide on the bottom plate *m*, in order that the gauge of the rollers may be adjusted at pleasure.

m. Bottom plate, on which the bearings rest.

n. Strengthening bar.

o o. Adjusting screws, by which the rollers can be set to any gauge, according to the degree of fineness to which the clay is required to be ground.

p. End beam of framing.

q q. Sides of framing.

r. Balance weight to horse beam.

The rollers in this mill are not faced in the lathe, but they are cast upright in loam moulds, which insures great accuracy in casting, and renders turning unnecessary, where only one set of rollers is employed. The arrangement of the rollers, when two or more sets are employed, is shown in chap. iv., figs. 1, 2, and 3, which shows the construction of the clay-mills used in Staffordshire.

The temporary floor on which the clay falls after passing between the rollers is formed about 8 feet below them, and is inclosed on three sides with brick walls which support the wooden framework of the machinery. The clay is prevented from adhering to the surfaces of the rollers by strong knives fixed on their under sides.

Fig. 5 is a diagram showing an improved arrangement of the ordinary clay-mill, in which the horse track is raised to the level of the top of the hopper, the whole of the machinery under the hopper being completely boxed up, so that no dirt or stones can lodge on the wheels. The driving wheel is placed in a circular pit lined with brickwork to keep up the horse track to the required height.

Fig. 6. Isometrical view of a moulding table.

A. Sloping plank, placed at one end of the table to enable the moulder's boy to deposit the clay on the table.

B. End of the table where the tempered clay is deposited.

C. Sand box. This is not always fixed to the table. In many cases it is a detached box, on three legs, placed close to the moulding table.

D. The part of the table on which the clot is moulded.

E. The place where the clot is put into the mould.

F. The water-box, in which the moulder dips his hands each time he moulds a brick.

G. A slip of wood on which the plane rests in order to raise it from the table, that the moulder may take it up the more readily.

H. The part of the table at which the brick is taken off. This part of the table is always very wet, and the slush runs off into

I. Gutter, to carry off the drippings from the table into a tub placed beneath it, but which is not shown in the drawing. If the water were allowed to run down on the working floor, the latter would soon become wet and slippery, and unfit for receiving the bricks.

Fig. 7. Copper brick mould.

This kind of mould is cast in four pieces and riveted together, the sides projecting half an inch beyond the ends. Each casting has a flange at top and bottom, forming a rim half an inch wide all round the top and bottom of the mould. These rims become gradually worn down by the friction of the plane and the action of the moulding sand, and require replating from time to time. The expense of replating with brass has induced a trial of iron rims, but they have not been found to answer. The outside of the mould is cased with wood, secured to the brass by the rivets. To give a hold to the latter, each pair is passed through a piece of sheet copper, as shown in the cut.

The moulds for making quarries are somewhat different, two of the sides only being cased with wood, whilst the others are stiffened by strengthening ribs cast on the sides of the mould.

Fig. 8. The plane.

Fig. 9. The clapper.

Fig. 10. Bench on which the best bricks are polished and dressed with a dresser, as described in art. 34.

Fig. 11. The dresser.

Figs. 12, 13, 14, 15, 16, and 17. Plans, sections and elevations of a kiln.

Fig. 12. Plan at level of floor, showing the firing sheds and fire-holes. The latter, in this example, are arched over, and are built of considerable width, which is afterwards reduced by temporary piers of brickwork. In many kilns, however, the fire-holes are made at once of the requisite width, and finished at top by oversetting the bricks on each side till they meet, instead of being arched over. The fire-brick lining to the fire-holes is indicated in the plan by a tint darker than that of the rest of the walls. The temporary piers of brickwork are shown in outline only. These are pulled down whenever the fire-brick lining requires to be renewed. The floor of the kiln is not paved.

Fig. 13. Plan, showing the roofs of the firing sheds (B B), and the steps (A) leading to the top of the kiln.

Fig. 14. Cross section of kiln, taken through the firing sheds, and showing the construction of the fire-holes.

Fig. 15. Longitudinal section, taken through the doorways at the ends of the kiln, and showing the appearance of the fire-holes in the inside.

Fig. 16. End elevation of kiln, showing the doorway and the ends of the firing sheds, as well as the steps leading to the top of the kiln.

Fig. 17. Side elevation, with the firing shed removed, in order to show the fire-holes.

Fig. 18. Perspective view of a kiln. This kiln is built very differently from that shown in the previous figures, the walls being very massive at the bottom, and diminishing in thickness as they ascend. The angles are strengthened by buttresses. The doorways do not reach to the top of the walls, and are arched over, so that the latter form a continuous terrace all round the top of the kiln, on which a thin parapet is built up in a temporary manner, to increase its capacity.

CHAPTER IV.

BRICKMAKING AS PRACTISED IN THE STAFFORDSHIRE POTTERIES. By R. Prosser, C.E.

1. *Bricks.*—There are made in this neighbourhood the following sorts of bricks for building, viz., red, blue, and drab, and also a blue brick used as a paviour for footways, which brick is called a dust brick, from the circumstance of coal dust being used when it is moulded. When fired it has a smooth and somewhat glossy surface, and being very durable is extensively used as a paviour.

2. The drab brick is used to a limited extent for building, but more generally as a fire-brick by potters and iron-masters; it is, however, inferior to the Stourbridge brick, the latter being used where intense heat is generated.

3. *Tiles.*—There is a variety of other articles made in the brick-yards of this locality, as, roofing tiles in several varieties, tubular drain tiles from 3 in. to 16 in. meter, and generally 18 in. long; also floor tiles or quarries both red and blue, the latter resembling the blue brick.

4. *Clay.*—The blue colour is obtained from the same clay that fires red by additional heat being generated when blue is required, at a cost of half a ton more coal, and two hours more time allowed per oven. The clays or marls are selected for the purposes to which they are best adapted, and an extensive supply of the best quality for red is procured at Cobshurst, about two miles south of Longton (which marl is used to make the red orna-

mental and encaustic tiles, now so much admired, and which are extensively made by Messrs. Minton and Co., of Stoke-upon-Trent). Marls and clays suitable for brickmaking are plentiful, and of several varieties, in this neighbourhood, but the most extensive bed of red marl runs in an almost unbroken line through this country from south to north, and generally west of the great coal-field, and is worked with the same results at Stourbridge, Tipton, Hanford, Basford, Tunstall, and other places. A reference to a map of the country will show the peculiarity of this long bed of stratified marls.

5. In the pottery district there are about ten distinct sorts or strata. The following names are given to the seven sorts most used; and their position with relation to the earth's surface is shown by the order of their names here given.

Top red marl, dun coloured, top yellow (rotten red, not used), mingled, bottom yellow, brown, and bottom grey.

Seven of these marls vary but slightly in their chemical composition, and, when used, three sorts at least are generally mixed together. (For an Analysis of the above-named marls, see Table 1, art. 37.)

In this locality there is a very favourable combination of circumstances for the manufacture of ornamental bricks for architectural decorations; and were architects to give the subject their attention much might be done.

6. The following description of the process and cost of brick and tile-making will apply, first, to the make of bricks, &c., upon the property of the manufacturer; and, secondly, to the make of tiles, &c., at a yard which is rented.

FIRST EXAMPLE.—BRICKMAKING.

7. *Buildings and Plant.*—This yard, with the ground opened for work, has an area of about 6 acres, and has the following buildings and machinery upon it, viz.:—

- A 5-horse power steam engine :
- A set of horizontal rollers ;
  - (Three pairs to the set, placed over each other).
- A pug-mill ;
- Six drying-houses ;
- And nine ovens.

The drying-houses measure 40 yards in length, by 8½ yards in width, and have two flues under the floor through their entire length.

At times they fire these nine ovens in one week ; and if used exclusively for bricks, each oven could be fired five times in a fortnight. Besides bricks, the following goods are made at this yard :—pipe tiles from 3 in. to 16 in. diameter, roof and ridge tiles, quarries, dust bricks, &c.

8. *Rate of Production.*—Provided the make were confined to bricks, with these conveniences they would make 100,000 weekly during the usual brick season, which at the present selling price for red and brindled bricks, £1 12*s.* 6*d.* per 1,000, gives a weekly produce value £162 10*s.*

9. *Tempering.*—The marls used at this yard answer to the description previously given. Their average contraction when mixed is 1 in 10 ; that is, a 10-in. mould gives a 9-in. brick when fired, although some of the varieties used separately contract 1 in 6. The marls are dug and wheeled two runs for 4*d.* to 7*d.* per cube yard, the price depending upon the difficulty of digging. The marl is then placed in a hopper over the topmost

rollers, and passing successively through the three pairs, is deposited on a floor about 8 ft. below the hopper. The marl is then wheeled away, and some three or more sorts mixed together with a proper quantity of water, by spade labour (for the quantity of water in the marl when dug, see Analysis, Table 1, art. 37). The mixed marls, if wanted for tiles or dust bricks, are now passed through the pug-mill; but if required for ordinary bricks, the ground marls are mixed with marls that have been weathered but not ground. Lastly, the marl is tempered by spade labour until the proper degree of plasticity is obtained.

10. *Moulding.*—The bricks are moulded by what is called the slop-moulding process at the rate of 3,000 per day.* The price paid for tempering and moulding is 5*s*. 0*d*. per 1,000. The process is as follows: the temperer wheels the prepared marl in a barrow up a plank, and empties it upon the moulding table. The moulder having sprinkled sand upon the moulding board, and upon that part of the table where the clot is moulded, takes as much clay as will fill the mould, and by a quick roll and a tap gives the clot an approximate form to the mould; he then lifts up this lump of clay about 12 in. high, and with force throws it into the mould, pressing it down with both hands to fill all the cavities, and strikes off the surplus with a wooden striker, which he throws into a small water-box in front of him after each time of using.† An attendant boy, who has previously dipped a mould in a water-trough by the side of the table, places it on the table ready for the moulder, and carrying away the moulded brick

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* In the neighbourhood of Nottingham, where the bricks are not stricken, but *planed*, the rate of production is only 2,000 per day.—ED.

† See chap. iii., art. 47.

in the mould, carefully empties it on its flat side on the floor; these operations are repeated until the floor is filled, when the moulding-table is removed to a second floor.

11. *Drying.*—The floors are of different sizes; a convenient size is 25 yards in length by 6 yards in breadth, upon which they will lay 3,000 bricks. Here they are allowed to dry until sufficiently hard to handle and place in hacks, the length of time depending upon the weather. In quick drying weather they will remain half a day as deposited from the mould, and half a day turned upon edge, and afterward they are placed up in hacks, where they remain until placed in the oven.

12. An ordinary blue brick weighs, wet from the mould, 12 lbs. 4 oz.; when fired it weighs 8 lbs. 1 oz., having lost by evaporation in drying and burning 4 lbs. 3 oz., or 34 per cent. of its original weight.

The specific gravity of an ordinary blue brick in the wet state from the mould is . . . 2,171
In the dry state, ready for the kiln . . 2,075
And when burned, the specific gravity is . 1,861

The Table on the next page shows the amount of evaporation during the process of drying.

The total loss of weight in drying and burning is as follows:—

196	ounces,	the weight of a brick wet from the mould.	
46	„	„	lost by drying, or 23½ per cent.
150	„	„	dry ready for the kiln.
21	„	„	lost in burning, or 14 per cent.
129	„	„	of an ordinary blue brick.

13. *Burning.*—The oven is of a circular form, with a

1848.	Times of Weighing.		Loss of weight in ounces.	Interval in hours between each weighing.	Loss of Weight in ounces in each 12 hours, the day and night.
		oz.			
August 3rd	at 7 A.M., weighed	196			
" "	11 " "	191½	4½	4	27½ in the day time, 12 hours.
" "	3 P.M., "	173¼	18¼	4	
" "	7 " "	169	4¼	4	
" 4th	7 A.M., "	163½	5½	12	5½ in the night, 12 hours.
" "	11 " "	157¾	5¾	4	10¾ in the day, 12 hours.
" "	3 P.M., "	153½	4¼	4	
" "	7 " "	152¼	1¼	4	
" 5th	7 A.M., "	150	2¼	12	2¼ in the night, 12 hours.
			46		

The loss of weight is 46 ounces by evaporation in drying, previous to being placed in the kiln to be fired or burned, or 23½ per cent. of its original weight.

spherical top, and will contain 8,000 bricks, which are so placed as to allow a space between the sides of each for the action of heat, and an equal diffusion thereof. When the oven is full, the clammins or doorway is made up, and the fires kindled and kept burning 36 hours for red, and 38 hours for blue bricks, consuming 3½ tons of coals for the former, and 4 tons for the latter. The

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expense of setting, firing, and drawing an oven of 8,000 bricks is as follows: labour 12s., and coals £1 16*s.*

14. *Cost of Manufacture.*—The details of the cost of manufacture are as follows:—

		£	*s.*	*d.*
Clay getting	per 1,000	0	2	0
Tempering and moulding	,,	0	5	0
Setting oven, firing and drawing . . .	,,	0	2	0
Coals, 4 tons at 9*s.* 0*d.*, divided amongst 8,000	,,	0	4	6
Rent, machinery, clay, contingencies, and profit	,,	0	19	0
Present selling price for ordinary red bricks	,,	1	12	6

15. *Rental.*—Brick-yards with mines of marls are set with the following appendages, viz.: 1 oven, moulding or drying-house, and pug-mill, with a breadth of brick floor and marl bank sufficient to work one oven for £30 per annum; if two ovens are worked in the take, they are set at £25 each.

DESCRIPTION OF ILLUSTRATIONS.

16. *Figs.* 1, 2, 3, *Machine, with three pairs of Rollers, for grinding Marl.*

Fig. 1. Side elevation.
Fig. 2. Front elevation, with the gearing removed.
Fig. 3. Elevation of gearing, No. 1 being the driving wheel.

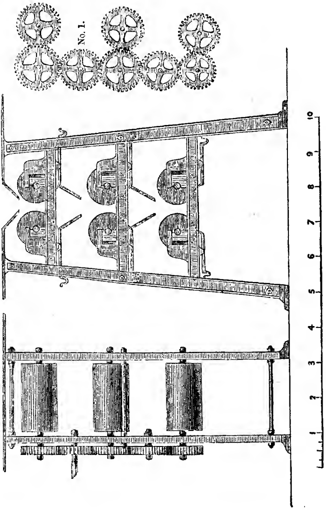
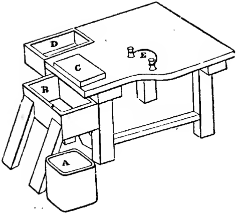


Fig. 3.

Fig. 2.

Fig. 1.

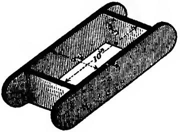
17. *Fig.* 4. *Isometrical View of a Moulding Table.*



A. Sand basket. B. Detached water-box. C. Moulding board
D. Water-box. E. Clay knife.

In the process of moulding the moulder takes in his hand, from the basket, a portion of sand, and dusts upon that part of the table where he rolls the clay into the form necessary to mould; also upon the moulding board. The water-box or trough, B, is used by the boy to wash the mould in, and is lower than the table, so as to be convenient for that purpose. The water-box, D, is level with the table, and is used to throw the strike in after each time of using.

18. *Fig.* 5. *Isometrical View of a Brick Mould.*



N.B. The mould is made of oak, the edges plated with iron.

19. *Figs.* 6, 7, 8, *and* 9. *The Oven or Cupola*

Fig. 6. Plan taken at top of fire-holes at level A B, *Fig.* 9.

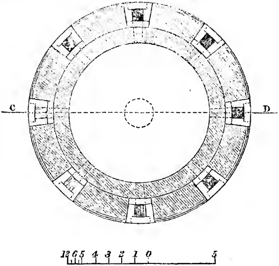


Fig. 7. Plan, looking down on top of oven.

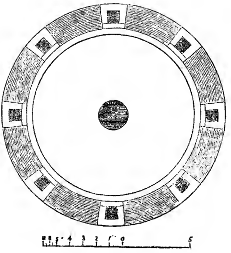


Fig. 8. Elevation.

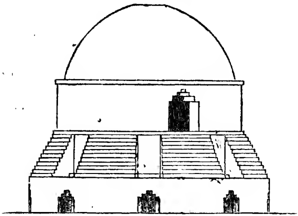
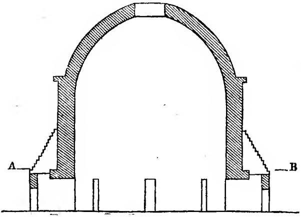


Fig. 9. Section, on line C D, *Fig.* 6.



SECOND EXAMPLE.—TILE MAKING.

20. At Basford there is an extensive hill of good marls from which eight brick-yards are supplied (working fourteen ovens), some of which have been in work for forty years. The makers are subject to the rental stated in art. 15. The leading article made at these yards is roofing

tiles; besides which are also made some quarries, dust-bricks, drain tiles, and just so many common bricks as are necessary for the manufacture of tiles, it being necessary, in order to set the oven properly, to burn 2,000 bricks with every oven of roof tiles, as will be hereafter explained. The process of tile making here is as follows:—

21. *Weathering and Tempering.*—The marl is dug and spread upon slopes of this hill (which has a south-east aspect) to weather; the length of time depends upon the quality of the air: a hot dry summer's day will do good service, and three or four such days would enable the makers to collect a thin surface in a workable condition. Frosty weather, provided it be dry, is preferred; wet, and alternations of wet and dry, retard the process of what is termed weathering. During a hot dry season marl can be dug, weathered, and made in one month, and this is frequently done. At the yards here referred to, the workers collect their marls, so weathered, at the foot of these slopes, and mix them with a quantity of water. That to be used for tiles is placed in the pug-mill, and about 1 cube yard per hour is ground by one horse; and that used for common bricks is not ground, but simply mixed and tempered.

The pug-mill consists of a wooden tub slightly tapered, the largest end being uppermost; it is circular and about 6 ft. high and 3 ft. diameter at the top or largest end, in which a cast-iron spindle revolves, carrying a series of flat steel arms, arranged so as to form by rotation a spiral or worm-like motion upon the clay, which is thereby pressed from a larger to a less diameter of the tub in which the clay is confined, and ultimately comes oozing out of an aperture at the bottom: this operation kneads the clay, and more completely mixes it, giving it great cohesive power. This clay or prepared marl is now ready to make roof tiles, dust bricks, quarries, &c., and is wheeled away to the stock kept under cover for that purpose. The tiles, and all articles in the making of which coal-dust is used, are made in a building called by brickmakers the *hovel* or drying house: but they prefer placing their tiles when first moulded in the open air, weather permitting. The moulding of roofing tiles varies from that of bricks before described, principally in the clay being stiffer, and coal dust being thrown in the mould each time it is filled.

22. *Moulding.*—The mould is 12 in. by 7¾ in. and ½ in. thick, made of oak plated with iron. The moulder at his bench takes up a lump of clay, and works it by hand into an oblong square, somewhat less than the mould, say 11 in. by 7 in. or thereabout; the mould is placed upon the bench, and fine coal-dust thrown into it; the man then takes up the lump of clay in the right position for the mould, and throws it into it with considerable force; then, with a brass wire strained upon a wooden bow, cuts off the surplus clay level with the mould, removes the lump, and finishes moulding the clay left in the mould by adding a little clay if it be wanted, and smooths it over with a wooden tool. By his side upon the bench he has two thin boards about the size of the moulded tile, their surfaces are dusted over with coal-dust; upon one of these he places the moulded tile, without the mould, the half circular projections extending beyond the board; and so he repeats the process of moulding at the rate of from 1,300 to 1,500 per day, adding more clay to his lump about every six tiles moulded, and in quantity about as much as the six tiles moulded.

23. *Drying.*—The attendant boy carries away two

tiles at each time to the floor; he takes up one on the board, and by the thick part of the hand presses up the two projections at right angles with the face of the tile, and then places board and tile on his head, and takes up a second and operates upon this in like manner, as he walks to the floor, where he lays the two tiles, carrying the boards back to the moulding bench; and so he repeats his operations.

The tiles remain on this floor, out of doors in fine weather, about four hours; they are then collected and placed close together, the nib end changed alternately to allow of their resting close and square; in this state they are walled up in a dry but not hot situation, and so remain for a day or two: this is said to toughen them.

24. *The Set.*—The next process is to give them a curved form, sometimes termed the set, which is done on a three-legged stool, called a horse, the top of which is a little larger than the tile, and is curved one way to about a 10 feet radius. With the horse is used a wooden block, curved to correspond with the surface of the horse. These implements are used as follows: six tiles are taken as last placed and put on this horse; the man lifts up the wooden block and gives them three sharp blows with it; they are then carried away and placed in an ingeniously built wall to complete the drying process (the wall built with the tiles to be dried), after which they are carried to the oven, twelve at each time, in a peculiar manner, with the edges of the tiles against the breast of the carrier.

25. *Quarries and dust bricks* are moulded in like manner from stiff clay, coal-dust being used to facilitate the articles leaving the mould.

26. *Drain Tiles.*—Pipe drain tiles are made as fol-

lows: the clay is first moulded to the length, width, and thickness required, and then wrapped round a drum, the edges closed together by hand, the drum or mandril turned round, and the pipe tile shaped by the operator's hand, assisted in some cases by a wooden tool: this is the mode of making pipe tiles from 3 in. to 16 in. in diameter, whether cylindrical, tapered, or egg-shaped.

The usual length is 18 in., and the diameter from 3 in. to 9 in. They are sold at 1*d*. per in. bore; that is, a pipe 3 in. in diameter and 18 in. long, would cost at the yard 3*d*.; and a pipe 9 in. in diameter and 18 in. long, 9*d*. This price applies to cylindrical pipes without sockets.

27. *Tile Machines.*—One of Ainslie's machines has been introduced into this neighbourhood, upon the estate of the Duke of Sutherland, for making small tubular drain tiles, which makes two pipes 1½ in. in diameter at the same time. The prepared clay is forced through two *dods* to form the tubes, which are cut into lengths by wires affixed to the machine, and when partially dry are rolled straight by hand upon a flat surface, and then set up in racks to finish the drying process.

28. *Firing.*—Firing the articles enumerated in the previous description requires much more care than firing bricks, and as roof tiles are the thinnest and require most care, the largest sized pipe tiles excepted, we shall describe firing an oven of such tiles.

On the bottom of the oven are first placed 2,000 bricks, as shown in fig. 13, and upon these are placed 7,000 tiles, forming a square, the spaces between the tiles and the curved side of the oven being filled up with bricks, as shown in fig. 14. The tiles are placed edgewise, in parcels of twelve, changing their direction each parcel of twelve. The nibs on the tiles space them off from each other, and support them in the vertical position; from this description, and a reference to the illustrations, it will appear, that the goods placed in the oven are in each case so placed as to allow the diffusion of heat between them; and as the uniformity of heat is the desideratum in firing blue bricks and tiles, the circular oven is found to answer better than any other at present in use.

It is necessary to have a wall round the outside of the oven, about 6 ft. high, and at a distance therefrom to allow the fireman space to attend his fires conveniently; this wall is dry built generally with imperfect bricks, and its use is to avoid one fire being urged more than another by the set of the wind, which duty it performs tolerably well.

The oven being set, the clammins (doorway) is made up with bricks daubed over with street sweepings as a loam; then the fires are kindled, and are kept slowly burning for the first 5 hours, after which they are progressively increased for the next 33, making 38 hours for hard fired blue tiles or bricks; four tons of coal being consumed in the firing. The heat is determined by the sight of the fireman directed to the mouths and top outlet of the oven. When the heat is obtained, and before the fires burn hollow, the mouths are stopped up with ashes to prevent the currents of cold air passing through the oven, which is then suffered to cool gradually. An oven is usually fired once a week, but may be fired three times in a fortnight. After firing, twenty-four hours should be allowed for cooling before an oven is opened to take out the tiles.

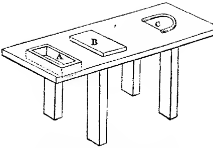
29. The following table shows the selling price per

1,000, and cost per superficial yard, of quarries, dust bricks, and roof tiles :—

Size.	Price per 1,000.	Superficial measurement per 1,000.	Price per superficial yard in pence.	Thickness.	Description.
6 in. sq.	35*s*.	27·89 yards.	15·00	1 inch	Quarries.
7 „	46*s*.	37·80 „	14·59		
9 „	80*s*.	62·50 „	15·36	1¼ „	„
9×4½	40*s*.	31·25 „	14·33	2 „	Dust bricks.
10 8×7 „	25*s*.	58·33 „	5·14	½ „	Roof tiles.

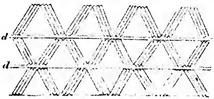
DESCRIPTION OF ILLUSTRATIONS.

30. ***Fig.*** 10. *Isometrical View of a Bench for moulding Tiles.*



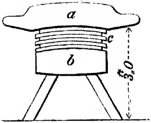
A. Coal-dust box, 14 in. by 8 in.
B. Moulding board, 14 in. by 10 in.
C. The bow.

31. ***Fig.*** 11. *Elevation, showing the Manner in which the Tiles are placed during the last Drying.*



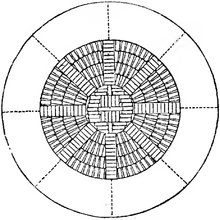
d d. laths, two to each course.

32. *Fig.* 12. *Tile Block and Horse.*



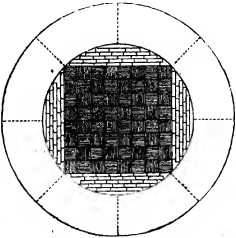
a. The block. *b*. The horse. *c* Tiles.

33. *Fig.* 13. *Plan of Oven, as seen when eight courses of Bricks are placed edgewise.*



The eight rows of twelve bricks in each, as seen in plan, cover a space left in continuation of flues from the eight fire-holes. The bricks in the first seven courses are so placed as to leave a flue of an average width of 4 inches. The dotted lines show the position of the fire-holes.

34. *Fig.* 14. *Plan of Oven, as seen when the first course of Tiles are placed upon the Bricks, as seen in Fig.* 13.



The tiles are placed in bungs of twelve, and laid alternately cross and lengthwise, the nib spaces them off, and supports them in a vertical position. Each side of the square is made up with bricks, as shown on the plan.

35. The manufacture of bricks, &c., for building and paving purposes, in a systematic manner, in suitable premises with improved conveniences, so that the operatives may be employed the whole of the year instead of a portion of it as now, is a subject deserving the attention of the capitalist and inventor. Improvements in the quality and conveniences of this manufacture are intimately connected with the moral, intellectual, and physical condition of society, as may be seen by a visit to any ordinary brickyard, and a reference to the evidence before the Sanitary Commission. Where extensive supplies of marls or clay are found, suitable works might be erected for such manufacture, could a

cheap and ready mode of transportation be commanded, so as to carry bricks, &c., a distance of 60 to 100 miles without materially increasing their price.

The railway charges for the carriage of bricks are so high as to preclude any resort to this mode of transit, except for the better kinds, such as ornamental and facing bricks, which must of necessity be brought from a distance, where they cannot be produced locally; but stock bricks and the other commoner kinds are seldom carried far from their place of manufacture unless, as often happens, this is situate near a canal or other means of water carriage.

Where these facilities exist the cost of carriage can be so considerably reduced, as compared with railway rates, that bricks can be, and often are, sent considerable distances. The bulk of the building bricks used in the Metropolis are brought by barges in this way either by river from Sittingbourne, or by canal from other districts on the north and west of London.

The great part now played by bricks and tiles in modern domestic architecture has led to great interest being taken in their manufacture, with the result that it has now reached a pitch of perfection never before attained.

37. ANALYSES OF CLAYS, ETC.

TABLE 1.—Analysis of Clays, Nos. 1, 2, 3, 4, 5 and 6, from Basford; 7 and 8 from the Staffordshire Potteries. By F. C. Wrightson, Esq., Birmingham.

	Red marl, which burns blue.	Dun coloured marl, burns good blue.	Top yellow marl, burns reddish blue.	Mingled marl, burns blue reddish.	Rotten red marl, will not stand the heat; it melts.	Mixture of clays, Nos. 1, 2, 3, and 4, burns good blue.	Clay from Stoke-upon-Trent, burns red, and will not burn blue.	Sagger marl, burns light buff—a fire-brick.
Number of Analysis	1	2	3	4	5	6	7	8
Silicic acid	69·87	64·32	65·78	70·17	42·84	59·44	60·02	54.38
Alumina	16·79	20·33	15·16	16·25	17·61	25·93	24·26	26·55
Peroxide of iron, with a little protoxide	8·88	10·86	8·49	8.41	6·97	10·74	9·14	—
Protoxide of iron, with a little peroxide	—	—	—	—	—	—	—	8·38
Lime	Trace.	Trace.	1·67	1·29	15·36	—	1·60	—
Carbonic acid	—	—	—	—	11.61	—	—	3·14
Oxide of manganese	—	—	—	—	2·20	Trace.	Trace.	—
Soda and a little potash	—	—	—	—	—	—	1·40	—
Water	4·26	6·60	5·37	5·86	3·94	3·11	3·89	7·23
	99·80	102·11	96·47	101·98	100.53	99.22	100·31	99·73

TABLE 2.—The Clays in Table 1 arranged in the order of infusibility, beginning with the most easily fusible clay, and calling that No. 1.

No.	1	2	3	4	5	6	7	8
Silicic acid	42·84	54·38	59·44	60·11	64·32	65·78	69·87	70·17
Number of Analysis in Table 1	5	8	6	7	2	3	1	4

TABLE 3.—The Clays in Table 1 arranged in the order of intensity of colour, beginning with the lightest shade.

Number of Analysis in Table 1	8	5	4	3	1	7*	6	2
Peroxide of Iron	about 1·	6·97	8·41	8·49	8·88	9·14	10·74	10·86

* Will *not burn* blue, burns *red.*

TABLE 4.—Showing the different proportions of bases contained in the Clays in Table 1.

Number of Analysis in Table 1	5	7	6	8	2	3	4	1
Alumina and other bases equivalent	50·91	35·18	32·93	32·65	27·33	23·66	23·65	22·59

No. 5, Table 1, contains 42·84 per cent. silicic acid; this requires, theoretically, 47·60 of alumina, or its chemical equivalent in other bases, to form a fusible compound; it therefore contains only 3·31 per cent. excess of base. This is insufficient to prevent its fusion—a much larger excess would. No. 1 contains 22·59 of base, which requires 25·1 of silicic acid, therefore 69·87 − 25·10 = 44·77 the excess of silicic acid, or *uncombined* silica in the clay, rendering it infusible.

ANALYSIS of COAL, called NORTON COAL, used in the potteries for burning pottery and bricks:—

Carbon	81·08
Hydrogen	5·04
Oxygen	10·55
Sulphur	0·36
Nitrogen	Trace.
Ash	2·97
	100·00

ANALYSIS of a porous substance which floats in water. It is a piece of a vitrified fort from Connel Ferry, near Dunstaffnage Castle, Scotland:—

Alumina and peroxide of iron	28·45
Silica	67·85
Lime	0·32
Manganese	Trace.
Water	1·88
	98·50

This specimen has the appearance of pumice-stone. It is only very slightly fusible even in the very highest temperature of the blow-pipe.

BRICKMAKING ON THE SOUTH STAFFORDSHIRE RAILWAY.

38. The following additional particulars respecting brickmaking in Staffordshire were sent to the author of this volume by Mr. J. L. Brown, of Farewell, near Lichfield, and are given in his own words:—

"The brickyard I visited is on the highway from Lichfield to Walsall, at a place called Walsall Wood; it is worked by Mr. George Brown, of the Sand Hills, near that place. Mr. B. has another brickyard in the neighbourhood, more extensive than the one I visited, and from these brickyards have been supplied all the bricks used for building the bridges, viaducts, cattle-arches, culverts, &c., &c., on the South Staffordshire Junction Railway.

"The brickyard I visited has six kilns or cupolas, and three large moulding and drying-sheds for use in the winter season, each 40 yards long by 8 yards wide, having fire-places at one end, and traversed by flues, longitudinally, to a chimney at the other end.

"The material used is not a clay, but a friable kind of marl. The first stratum under the surface soil is about 4 ft. thick, very compact in body, and requires the pick to get it; it is of a purplish hue. This is succeeded by a stratum, 3 ft. thick, of bright yellow-looking marl, equally intermixed with marl, of a bright scarlet colour, and afterwards, down to the depth of 20 ft., the purple-coloured marl comes in again.

"The earth in its raw state is drawn up an inclined plane on a common railway truck, by a steam-engine of 20-horse power, and at the top of the incline it tips itself into a hopper placed over the cast-iron rollers, between which the marl passes and comes down an inclined board, after being ground quite small. It is afterwards wheeled into heaps and tempered, and is then wheeled up an inclined plane of earth to the engine-house, where it is passed through vertical cylinders of cast iron, in the centres of which are revolving pistons armed with flanges, like the screw propeller of a steam vessel, which grind the tempered clay and force it through holes in the bottoms of the cylinders to chambers beneath them, whence it is wheeled to the moulders.

"They make red and blue bricks of the same marl, prepared in each case by rolling and grinding. To make the blue bricks, they keep the fires very much sharper and hotter, which changes their colour, and seems to run or fuse the material more, giving them at the same time a shining appearance. They make very few red bricks.

"The price of the best bricks at the kiln is 30*s*. per 1,000; common bricks, 25*s*. per 1,000. Plain-tiles for roofing, 28*s*. to 32*s*. per 1,000. They also make chimney-pots, pipes for the conveyance of water, splayed bricks, coping bricks, and bricks to any model."

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CHAPTER V.

BRICKMAKING IN THE VICINITY OF LONDON.

1. For facility of reference, we propose to divide the subject under three heads, as follows :—

1st. Materials and Plant.
2nd. Process of Manufacture.
3rd. Cost of Manufacture.

1. MATERIALS AND PLANT.

2. *Brick-earth.*—The brickmakers in the vicinity of London at present derive their principal supplies of brick-earth from the alluvial deposits lying above the London clay, the blue clay not being used for brickmaking at the present day. The general character of

the brick-earth may be described as being a gravelly loam, passing by fine gradations into either a strong clay or into marl, or, as it is technically called, malm, an earth containing a considerable quantity of chalk in fine particles. We may, therefore, for the purpose of description, class the several qualities of brick-earth under three heads, as follows:* strong clay, loam, and malm.

3. 1st. *Strong Clay.*—This is generally sufficiently free from stones to be used without washing, and the bricks made from it are hard and sound, but are liable to crack and contract very considerably in drying, and become warped and misshapen in burning. These defects are in a great measure removed by mixing the earth with chalk, reduced to the consistency of cream, as will be presently described, which greatly diminishes the contraction of the clay, and improves the colour of the brick.

4. 2nd. *Loam.*—The loams are often so full of gravel that it is impossible to free them from stones, except by passing the earth through the wash-mill. The quantity of sand present in these earths renders them less liable to shrink and warp than the strong clays; but, on the other hand, the texture of the earth is so loose and incoherent, that a mixture of chalk is necessary to bind the mass together, and to take up the excess of fusing silica in the process of burning.

5. 3rd. *Malm.*—This is an earth suitable for making bricks, without any addition, but there is very little now to be had, and for making the best qualities of bricks (or, as they are called, malms) an artificial malm is made,

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* It may be observed that this classification is such as would be best understood by the generality of readers, but would not be comprehended by most brickmakers, who class these three qualities of brick-earths as strong clay, mild clay, and malm. When the clays are strong, they are said, in brickmakers' language, to be *foul.*

by mixing together chalk and clay, previously reduced to pulp in wash-mills. This pulp is run off into shallow pits, where it remains until, by evaporation and settlement, it has become of sufficient consistency for subsequent operations. This process is adopted for the best qualities of bricks only, as the expense of it is very considerable; and, for the commoner sorts, all that is done is, to mix with the loam or clay a sufficient quantity of malm to make it suitable for brickmaking: the quantity of malm required for this purpose varies, of course, according to the quality of the earth.

6. It will be readily understood, from the above remarks, that the mode of preparing the clay differs greatly in different yards. The brick-earth (according to its quality) being used—

1st. Without either washing or malming.

2nd. It may be malmed, *i.e.*, covered with artificial malm.

3rd, and lastly. The bricks may be made entirely of malm.

The second process is the most common, and we propose, therefore, in the following pages, to describe the successive operations of brickmaking as practised at those works where the loamy character of the earth renders the malming indispensable. This will enable the reader to understand the first and third methods of treating the brick-earth without any further description.

7. The object of adding chalk to the clay is twofold. In the first place it acts mechanically, in diminishing the contraction of the raw brick before burning; and in the second place it acts chemically, as a flux during the burning, combining with the silica of the clay, so that a well-burnt London brick may be described as a silicate of lime and alumina, and, therefore, differs

greatly from an ordinary red kiln-burnt brick made of pure clay, without lime or alkaline matter, the silica and alumina of the brick-earth being, in the latter case, merely in mechanical and not chemical combination.

8. *Soil.*—The process of malming is not the only peculiarity of London brickmaking. Instead of the bricks being burnt in close kilns, as is the practice in most country yards, "clamping" is universally resorted to; and to render this effective, it is considered necessary that the fuel should be mixed up with the brick-earth, so that each brick forms, as it were, a fire ball, and becomes thoroughly *burnt* throughout, instead of being merely *baked,* as is the case in kiln burning. The fuel used in clamp burning is domestic ashes, or, as they are technically called, *breeze.* The ashes are collected in large heaps, and sifted; the siftings, which are called *soil,* being mixed with the brick-earth, and thoroughly incorporated with it in the processes of soiling and "tempering," whilst the cinders, or "breeze," are used as fuel. A small quantity of coal and wood is also made use of in lighting the clamp.

The soil, or sifted ashes, materially assists in preventing the contraction of the raw bricks whilst drying, and the sulphur contained therein appears to assist in colouring the bricks when burnt.

9. *Sand.*—The moulding sand is brought, at a considerable expense, from the bed of the river Thames, near Woolwich. It is spread out to dry in the sun in thin layers, which are repeatedly raked over, so as to expose every particle in succession to the sun's rays, that the whole may be perfectly dry when brought to the moulding stool. The moulding sand serves many useful purposes. It assists in preventing the contraction of the clay, and gives a more durable surface to the bricks. It is indispensable to the moulder for pre-

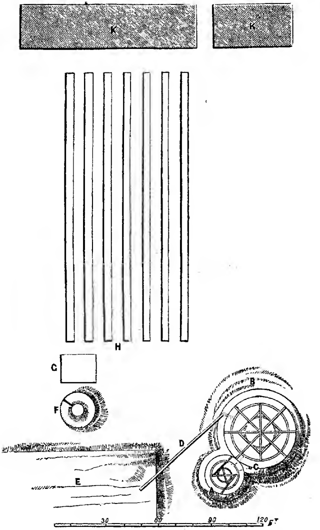
venting the bricks from sticking to his mould. It also prevents the bricks from sticking together on the hacks, and from breaking up into cracks and flaws when cooling, after being burnt. Lastly, the salt in the river sand becomes decomposed in the burning, and assists in fluxing the brick-earth, and in giving the bricks their grey colour. Common sand burns of a red tint, and would injure the colour of the London bricks.

10. *General Arrangement of a Brickwork.*—This will be readily understood by reference to fig. 1. The brick-earth is turned over to receive the malm as near as possible to the clay pits. The clay and chalk mills are placed close together in some convenient position, so as to interfere with the works as little as can be helped, and the malm is conveyed from them to the heap of brick-earth, by means of troughs or shoots supported on tressels.

Close to the brick-earth, and immediately behind the moulding stool is placed the pug-mill, and in front of the moulding stool is the hack ground, which should, if possible, be laid out with a gentle fall towards the clamps, which is placed at its furthest extremity. These arrangements are of course much modified by the circumstances of the locality.

11. *The Chalk and Clay Mills.*—These washing-mills are placed close together on a large double mound, sufficiently elevated to allow the malm to run down freely to the brick-earth. The chalk-mill is a circular trough lined with brickwork, in which the chalk is ground by the action of two heavy wheels with spiked tires, made to revolve by either one or two horses. The trough is supplied with water by a pump, the lever of which is worked by the machinery of the clay-mill, and as the chalk becomes ground into pulp it passes, by

Fig. 1.



means of a shoot, into the clay-mill. The clay-mill is also a circular trough, lined with brickwork, but much larger than that of the chalk-mill; and in this trough the clay is mixed with the pulp from the chalk-mill, and is cut and stirred by knives and harrows put in motion by two horses, until the whole mass is reduced to the consistency of cream, when it passes off through a brass grating into the troughs or shoots, and is conducted to the brick earth which has been heaped up to receive it. The machinery of the washing-mills is very fully delineated in figs. 2 to 10, and is described in detail in arts. 53 and 54.

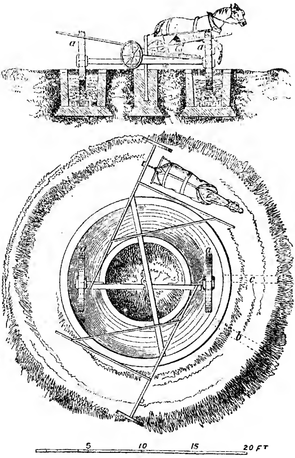
12. *The Pug-mill.*—The pug-mill used in brick-making is a conical tub, with its larger end uppermost, in the centre of which is a revolving vertical shaft of iron, to which are attached horizontal knives, inclined so that the clay is slowly forced downwards by their motion. The top and bottom knives are called *force knives*, and their use is merely to force the earth through the mill, and out at the ejectment hole; all the other knives are furnished with cross knives, which assist in cutting the clay, and breaking up any hard lumps that may not have been broken up by the previous wintering and turning over. In order to feed the mill, an inclined barrow-run is laid up to it, to enable the wheeler to tip the clay in at the top.

The construction of the pug-mill is shown in figs. 11 and 12.

13. *The Cuckhold,* fig. 13, is an instrument for cutting off lumps of the tempered clay for the use of the moulder, as it is ejected from the pug-mill, and requires no particular description.

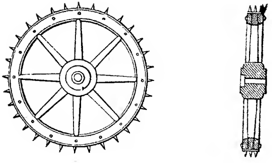
14. *The Moulding Stool.*—The moulding stool is quite different from that used in most parts of the

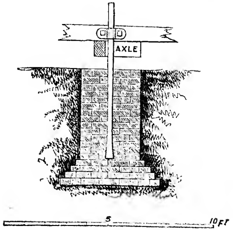
Figs. 2 and 3.



country. It has a rim at each end, to keep the moulding sand from falling off, and is provided with a *stock-board,* which forms the bottom of the brick mould, and with a

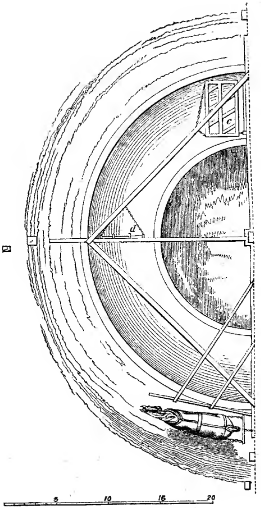
Figs. 4 and 5.





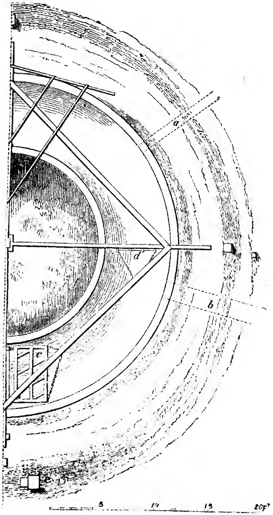
page, which is formed with two rods of $\frac{3}{8}$ iron, nailed down at each end to the wooden rails on which they rest. The use of the page is to slide the raw bricks more readily from the moulder to the place from whence they are taken and put upon the hack barrow by the "taking-off" boy. The moulder, when at work, stands

Fig. 6.



near the middle of the stool, with the page on his left hand, and his assistant, the clot-moulder, on his right.

Fig. 6.



The moulding sand for the use of the moulder and clot-moulder is placed in separate heaps at the opposite ends

Fig. 7.

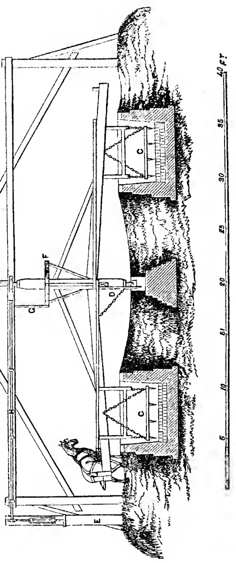
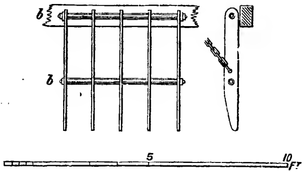
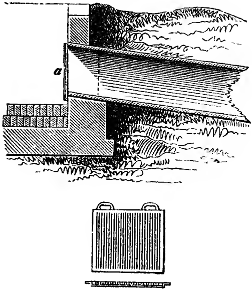


Fig. 8.

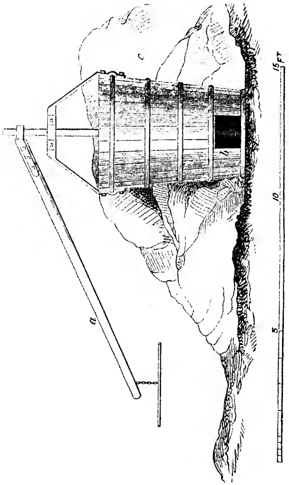


Figs. 9 and 10.



ot the stool, and the tempered clay nearly opposite to **the moulder.** There is no water-box, but a tub is placed

Fig. 11.



on the stool, into which the strike is thrown when not in use. The pallets are placed at one end of the page,

Fig. 12.

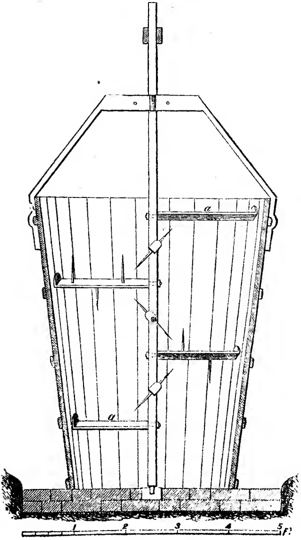
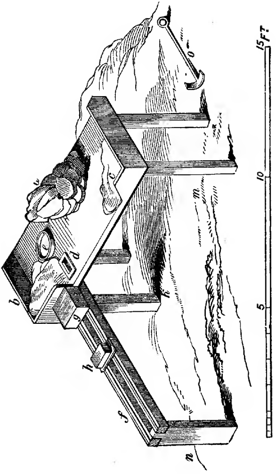


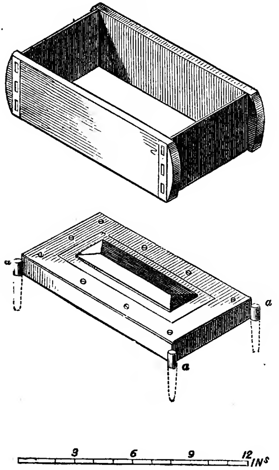
Fig. 13.



and close to the moulder's left hand. These particulars will be fully understood by reference to fig. 13. and to the detailed description in art. 56.

15. *The Brick Mould* is made of sheet iron, in four pieces, riveted together at the angles, and strengthened with wood at the sides only. The bottom of the mould is detached, and forms what is called the *Stock-board.* See fig. 14.

Fig. 14.



16. *The Stock-board* is a piece of wood plated with iron round the upper edge, and made to fit the mould

accurately, but easily. At each corner an iron pin is driven into the moulding stool, and on these pins the bottom of the mould rests, the thickness of the brick being regulated by the distance to which the pins are driven below the top of the stock-board. The hollow in the bed of the brick is produced by a rectangular piece of wood, called a *kick*, of the size and shape of the hollow required, which is fastened on the upper side of the stock-board.

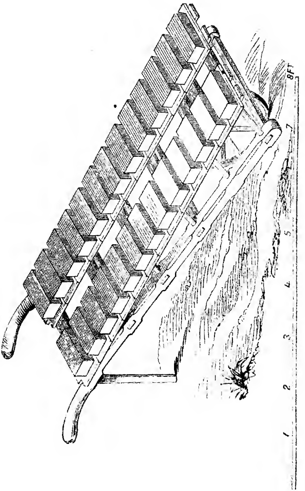
17. *The Strike* is a smooth piece of wood, about 10 in. long by 1½ in. wide and ½ in. thick, and is used to remove the superfluous clay in the process of moulding.

The Pallets are pieces of board ⅜ in. thick, and of the exact width of the mould, but about ¾ in. longer. Three sets of pallets, twenty-six in each set, are required for each moulder at work.

18. *The Hack Barrow*, figs. 15 and 16, is of a peculiar construction. It consists of a light frame, supporting a flat top of lattice work, on which the bricks are placed in two parallel rows, thirteen in each row. Three barrows are required for each moulder.

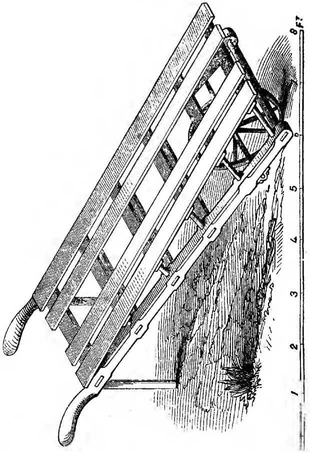
19. *The Hack Ground* occupies the space between the moulding stool and the clamp. It should be well drained, and it is desirable that it should be on a slight fall towards the clamp, as this lessens the labour of wheeling. The foundations of the hacks are slightly raised. It is of importance that the barrow-runs between the hacks should be perfectly even, as any jolting of the hack barrow would injure the shape of the raw bricks, which, when first turned out of the mould, are very soft. The hacks are placed 11 ft. apart, measured from centre to centre, their length varying according to the shape of the ground. It is very difficult to say

Fig. 15.



what extent of hack ground should be allotted to each moulding stool, as this varies greatly in different yards. In round numbers, the quantity of land required for a brickwork may be stated at from 1½ to 2 acres for each

Fig. 16.



moulding stool, but this includes the whole of the land required for the several purposes.

II.—PROCESS OF MANUFACTURE.

20. *Clay Digging.*—The first turning over of the brick-earth should take place in the autumn, in order that it may have the benefit of the winter frosts before

being used. The vegetable mould and top soil having been wheeled to spoil, the brick-earth is turned up three or four spits deep, and laid on a level floor, prepared for the purpose, and banked round to prevent the escape of the malm in the process of malming.

21. The quantity of clay required per 1,000 bricks is variable, of strong clay more being required than of milder qualities.

It is generally calculated that an acre 1 ft. deep, or about 1,600 cubic yards of clay, will make 1,000,000 bricks, but strong clays will require from 182 to 200 cubic yards per 100,000 bricks. For practical purposes the quantity may be thus approximately stated:—

Strong clay 2 cubic yards per 1,000 bricks.
Mild clay 1¾ cubic yard per 1,000 bricks.

22. *Malming.*—It has been before explained that the best bricks only are made entirely of malm, but that the process of malming is resorted to for other descriptions of bricks, where the quality of the clay renders it unfit for brickmaking without this addition. It will, therefore, be readily understood that the quantity of malm mixed with the clay in the ordinary process of brickmaking varies very considerably, so that it is impossible to say, *à priori,* what quantity of malm should be used, as this must be left to the judgment of the brickmaker in each particular case, according to the quality of the earth.

To keep the washing-mills in full work are required—

To the chalk-mill, 2 diggers and 1 wheeler.
To the clay-mill, 4 diggers and 2 wheelers.

The chalk-mill is worked sometimes with one, and sometimes with two horses. The clay-mill always requires two horses. No drivers are required.

The average work of the washing-mills, working 10 hours a day, may be taken at about 12 cubic yards of malm,* or sufficient for making 6,000 malm bricks.

The process of malming scarcely requires description. Water having been pumped into the troughs, chalk is wheeled to the chalk-mill, and clay to the clay-mill, and the horses being driven round, the chalk is crushed and ground by the wheels, and runs through the outlet into the clay-mill, where both chalk and clay get well mixed by the harrows, the liquid malm flowing out through the brass grating to the shoots, by which it is conducted to the brick-earth. As the heap becomes covered the shoots are shifted, so that the malm shall be equally distributed over every part of the heap.

When a sufficient quantity of malm has been run off, it is left to settle for a month or more, until it has become sufficiently consolidated to bear a man walking over it. As the solid portion of the malm settles, the water is drained off from time to time, and when the mass is sufficiently firm, the *soiling* is proceeded with.

23. *Soiling*.—The proportion of ashes depends very much on the quality of the earth, but may be stated approximately at about 35 chaldrons for every 100,000 bricks. The soil is laid on the top of the malmed earth, the thickness of the layer depending on that of the heap, about 3 in. of ashes being allowed for every spit of earth.

The soiling concludes the preparation of the brick-earth, which is allowed to remain undisturbed until the moulding season, which generally commences in April. The first process of the actual manufacture is—

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* At a manufactory of artificial hydraulic lime at Meudon, near Paris, the chalk and clay are ground together in a washing-mill, of the same construction as those used in England, and worked by two horses. The quantity of malm produced is about 1½ cubic yard per hour.—See Vicat on Cements.

24. *Tempering.*—The heap, prepared as above, is turned over by spade labour, and the ashes thoroughly incorporated with it, water being added to bring the mass to a proper consistency. The tempered clay is then wheeled to the pug-mill, which, as before stated, is placed close to the clay heap, and immediately behind the moulding-stool.

25. *Pugging.*—The tempered clay being thrown in at the top of the mill, gradually passes through it, and in so doing becomes so thoroughly kneaded as to be of a uniform colour, the ashes being equally distributed through the mass. The quantity of clay ground is about 1¼ cubic yard per hour, so that a horse working 10 hours per diem will grind 12½ cubic yards of clay, or sufficient to make 6,250 bricks.

If the moulding process does not proceed as fast as the pugging, so that the clay will not be immediately used, the clay, as it comes out at the bottom of the mill, is removed with the cuckhold, and covered with sacks, to keep it from becoming too dry for use.

26. *Moulding.*—Before commencing moulding, the moulding-stool is provided with two heaps of dry sand, a tub of water, in which to place the strike, a stock-board and brick-mould, and three sets of pallets. Everything being in readiness, and a supply of tempered clay having been placed on the stool by the feeder, whose business it is to carry the tempered clay from the pug-mill to the moulding-stool, the *clot-moulder*, who is generally a woman, sprinkles the stool with dry sand, and taking a *clod*, or *clot*, from the heap of tempered clay, dexterously kneads and moulds it roughly into the shape of a brick, and passes it to the moulder on her

left hand. The moulder, having sprinkled sand on the stock-board, and dashed the mould into the sand-heap on his left hand, places the mould on the stock-board, and dashes the clot into it with force, pressing it with his fingers, so as to force the clay into the angles of the mould. He then, with the strike, which has been well wetted in the water-tub, removes the superfluous clay, which he throws back to the clot-moulder to be remoulded. The mould is then lifted off the stock-board, and placed by the moulder against one of the pallets, which he catches dexterously with his fingers, and, turning out the raw brick upon it, slides it along the page to the taking-off boy, and, lifting up the empty mould, dashes it into the sand, and replaces it on the stock-board, preparatory to moulding a second brick; when he has moulded one set of bricks, he scrapes away the sand which has adhered to the mould during the operation with the strike, and then proceeds with the next set. A moulder and clot-moulder, with the assistance of a feeder, a taking-off boy, and two men to wheel and hack the bricks, will make about 5,000 bricks between 6 A.M. and 6 P.M.; but this quantity is often exceeded.*

27. *Hacking.*—The raw brick is removed from the page by the taking-off boy and placed on the hack barrow, and when the latter is loaded, dry sand is sprinkled over the bricks, and they are carefully wheeled away to the hack ground. Having arrived at that part of the ground where the hack is to be commenced, the man takes a spare pallet and places it on

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* See the following:—"Brickmaking. On Wednesday last, Jos. Rush, at Peterskye, Cumberland, performed the feat of making 1,000 bricks in an hour; 100 in five minutes; and 26 in one minute."—*Carlisle Journal.* (This is not a solitary instance.)

one of the bricks, which he carries between the two pallets to the ground, and sets it up carefully edgeways, taking care in removing the pallets not to injure the shape of the soft brick. One of the pallets is replaced on the barrow, and with the other another brick is removed; and the process is repeated till the twenty-six bricks have been placed on the ground, when the empty barrow is wheeled back to the moulding stool. In the meantime another barrow has been loaded, and is ready for wheeling to the hack ground. Three hack barrows are required, so that one of them is constantly being unloaded upon the hack ground, another loading at the moulding stool, and the third being wheeled to or from the hack ground. Thus two men are necessarily employed in the operations of wheeling and hacking. The hacks are set up two bricks in width, the bricks being placed slantwise, and not at right angles, to the length of the hack. After the bottom row of one hack is completed, a second hack is commenced, to give the bricks time to harden before a second course is laid on them; and when the second course is commenced, the bricks must be placed fairly on each other, or they will be marked, which injures their appearance. The hacks are carried up in this way until they are 8 bricks high, when they are left for a few days to harden. To protect the new bricks from frost, wet, or intense heat, straw or reeds are provided and laid alongside the hack, and with these the bricks are carefully covered up at night, and at such other times as the weather may render necessary. When half dry, they are *scintled*,* that is, set farther apart, to allow the wind to pass freely between them, and they receive no further attention until sufficiently dry for burning. The time required for drying varies from three to six weeks, according to the weather.*

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* Literally, scattered.

28. *Clamping.*—Figures 17, 18, 19, 20, and 21. The process of clamping requires great skill, and its practical details are little understood, except by the workmen engaged in this part of the manufacture. Scarcely any two clamps are built exactly alike, the differences in the methods employed arising from the greater skill or carelessness of the workmen, and local circumstances, such as the situation of the clamp, and the abundance or scarcity of burnt bricks in the yard with which to form the foundation and the outside casing. We propose, therefore, first to describe the method of building a clamp, according to the most approved system, and then to explain the principal variations practised in different yards.

29. A clamp consists of a number of walls or *necks*, 3 bricks thick, about 60 bricks long, and 24 to 30 bricks high, in an inclined position on each side of an *upright* or double battering wall in the centre of the clamp, the upright being of the same length and height as the necks, but diminishing from 6 bricks thick at bottom to 3 bricks thick at top. The sides and top of the

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* Mr. H. Chamberlain, in a paper read before the Society of Arts, IV. 515, speaks of the great importance of drying bricks :—"The drying of bricks ready for burning is a matter of great importance, and requires more attention than it generally receives. From hand-made bricks we have to evaporate some 25 per cent. of water before it is safe to burn them. In a work requiring the make of 20,000 bricks per day, we have to evaporate more than 20 tons of water every 24 hours. Hand-made bricks lose in drying about one-fourth of their weight, and in drying and burning about one-third. The average of machine bricks—those made of the stiff plastic clay—do not lose more than half the above amount from evaporation, and are, therefore, of much greater specific gravity than hand-made ones." The artificial drying of bricks over flues can of course only be carried on where coal is cheap. Mr. Beart has contrived a steam chamber, where steam made to circulate in pipes is the source of heat for drying the bricks.

Fig. 17.

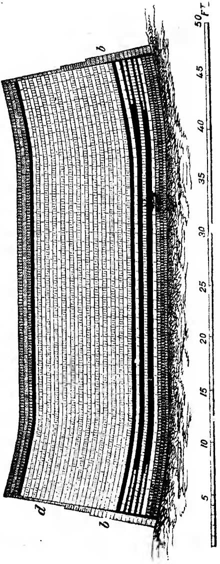


Fig. 18.

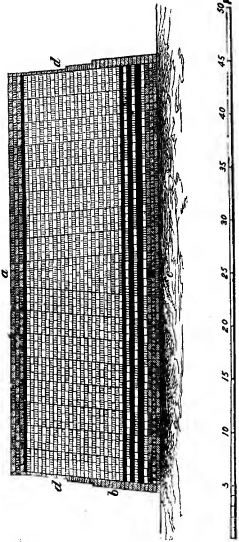


Fig. 20.

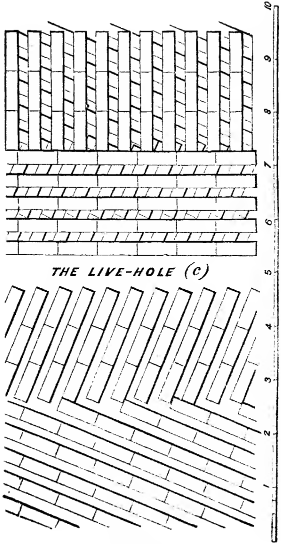
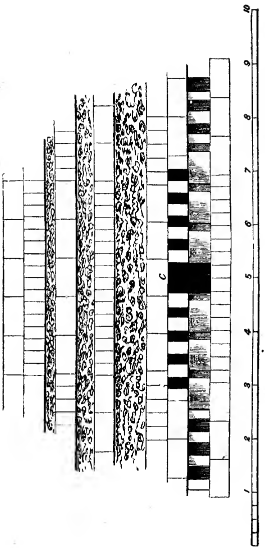


Fig. 19.

Fig. 21.



clamp are cased with burnt brick. The fuel used in burning the laid bricks consists of cinders (breeze, as before described), which are distributed in layers between the courses of bricks, the strata of breeze being thickest at the bottom. To light the clamp, *live holes* or flues, 7 in. wide and 9 in. high, are left in the centre of the upright, and at every 7th or neck. These live holes extend through the whole thickness of the clamp, and are filled with faggots, which, being lighted from the outside, soon ignite the adjacent breeze. As soon as the clamp is fairly lighted, the mouths of the live holes are stopped, and the clamp burns until the whole of the breeze is consumed, which takes from three to six weeks. This description will give the reader a general idea of the arrangement of a clamp; and we will now describe in detail the manner of building one, premising that the term *close bolting* signifies stacking bricks so that they shall be perfectly close to each other; and that *scintling* means stacking bricks with spaces between them.

30. *Foundation.*—The ground is first carefully drained and levelled, and made perfectly firm and hard. The exact position of the clamp having been fixed, the ground is formed with a flat invert whose chord is equal to the width of the intended clamp. The object of this is to give a *lift* to each side of the clamp, which prevents the bricks from falling outwards as the breeze becomes consumed. The ground being prepared, the upright is commenced. But, previous to building, the clamp barrow-roads or tramways of sheet-iron are laid down between the hacks, and extended to the clamp ground, to give an easy motion to the barrows; as, from the kind of barrows used in clamping, the bricks being piled on each other several courses high, and the

wheeling carried on with considerable velocity, they are apt to upset.

31. *Upright.*—The upright is commenced by building two 9 inch battering walls about 45 ft. apart, of burnt bricks laid on edge, which are termed close bolts, the length of each wall being equal to the thickness of the upright, which at the bottom is 6 bricks thick, or about 4 ft. 6 in. (their height is 16 courses, or about 6 ft.). Between these bolts a line is stretched, by which the upright is built true. The ground between the bolts is paved with burnt bricks laid on edge, to exclude the moisture of the ground. Upon this paving are laid two courses of burnt bricks with spaces between them, termed scintles. In the bottom course of *scintles* the bricks are laid diagonally about 2 in. apart. The second course consists of burnt bricks on edge, laid across the lower one, in lines parallel to the ends of the clamp, and also 2 in. apart. In laying these two courses of scintles, a live hole is left about 7 in. wide, the whole length of the upright; and, on the completion of the second course, the live hole is filled up with faggots, and the whole surface covered over with breeze, which is swept or scraped into the spaces left between the bricks. On this surface is placed the first course of raw bricks, laid on edge and quite close, beginning over the live-hole. Over this first course of raw bricks is laid a stratum of breeze 7 in. thick, the depth being increased, at the ends of the uprights, to 9 or 10 inches, by inserting three or four bricks on edge among the breeze. The object of this is to give an extra lift to the ends. The first course of bricks, it should be observed, is laid *all headers*. Over the first layer of breeze is laid a second course of raw bricks on edge, *all stretchers*. This is covered with 4 in. of breeze, and at each end are inserted

two or three bricks to increase the lift still more; but this time they are laid flat, not edgeways. Upon the 4 in. layer of breeze is laid a heading course of raw bricks laid close, and on this 2 in. of breeze, without any extra lift at the end. To this succeed stretching and heading courses of raw bricks on edge, laid close up to the top of the clamp, a layer of breeze, not more than ⅜ in. thick, being placed on the top of each course, except on the top course, which has 3 in. of breeze. The top of the upright is finished by a close bolt of burnt bricks. The upright is built with an equal batter on each side, its width diminishing from six bricks lengthways at the base to three bricks lengthways at the top. In order that the upright should be perfectly firm, it is necessary that the bricks should be well tied in at the angles; and, in order to obtain the proper width, the bricks are placed in a variety of positions, so that no very regular bond is preserved, as it is of more consequence to keep the batter uniform.

The close bolts first commenced, and which form the outer casing of the clamp, are not built close to the raw bricks, there being a small space left between the clamp and the close bolting, which is filled up with breeze. The close bolts, however, are built with a greater batter than the ends of the upright, so that they just touch the latter at the 16th course, above which the clamp is built without any external casing. When, however, the upright is *topped,* and whilst the top close bolting is going on, the casing is continued up to the top of the clamp. This upper casing is called the *bestowing,* and consists of five or six courses of burnt brick laid flat, forming a casing 4½ in. or half a brick thick; and above the 6th course the bricks are laid on edge, forming a still thinner casing only 3 in. thick. When the weather is bad, and during the latter part of the brickmaking season, a little extra bestowing is given beyond what is here described. The great art in clamping consists in the proper construction of the upright, as the stability of the clamp depends entirely upon it.

32. *Necks.*—The remainder of the clamp consists of a number of necks or walls leaning against the upright. They are built in precisely the same way as the upright, as regards invert, close bolts, paving, scintling, breeze, and end lifts. But there is this essential difference, viz., that they are *parallel* walls, built in alternate courses of headers and stretchers laid on edge, each heading course in one neck being opposite to a stretching course in the next neck, and *vice versâ*. The thickness of each neck is made up of three bricks lengthways in the heading courses, and ten bricks edgeways in the stretching courses. The necks are close bolted at top, and bestowed in the same manner as the upright. When the last necks have been built, the ends of the clamp are close bolted, and bestowed in the same way as the sides, and this operation completes the clamp.

33. *Firing.*—The number of necks on each side of the upright may be extended to eight or nine, without an additional live hole; but if this limit be exceeded, additional live holes are required, according to the judgment of the brickmaker or the demand for bricks; the live holes are placed seven, eight, or nine necks apart. It is not necessary that the additional live holes should pass under the centres of the necks, and it is more convenient to form each live hole so that the face of the last-built neck shall form one of its sides.

In the close bolting surrounding the clamp, two bricks are left out opposite the end of each live hole, and to each of these openings a fire is applied made of coals, and wood heaped up in a brick fire-place built round the opening, and known by the name of a *devil-stove*. The fire is kept up for about a day, until the faggots in the live hole are thoroughly ignited, and as soon as this is found to be the case, the fire is removed, and the mouth of the live hole stopped with bricks, and plastered over with clay. In firing a large clamp with many live holes, it should be begun at one end only, the live holes being fired in succession, one after the other.

The bricks at the outside of the clamp are underburnt; they are called *burnovers*, and are laid aside for reburning in the next clamp that may be built. The bricks near the live holes are generally partially melted and run together in masses called clinkers or burrs. The bricks which are not fully burnt are called place bricks, and are sold at a low price, being unfit for outside work, or situations where they will be subjected to much pressure. The clinkers are sold by the cart-load, for rockwork in gardens and similar purposes.

34. The quantity of breeze required varies much with the quality of the earth. The usual proportions for every 100,000 bricks are about 35 chaldrons of the sifted ashes, mixed with the brick-earth, and about 12 chaldrons of the cinders or breeze to light the clamp.

The quantity of fuel to the live holes it is difficult to calculate; about 2*s.* may be taken as the average cost of coals and wood for every 100,000 bricks.

35. If the proportion of breeze be too small, the bricks will be underburned, and will be tender and of a pale colour. If too much fuel be used, there is danger of the bricks fusing and running into a blackish slag. No rules can be laid down for avoiding these errors, as the management of the breeze must depend upon the quality of the earth, and can only be learnt from

experience, some brick-earths being much more fusible than others.

36. The time of burning varies considerably. If expedition is requisite, the flues are placed near together, and the burning may be completed in a fortnight or three weeks; but, if time is no object, the flues are further apart, and the clamp is allowed to burn off more slowly.

37. Another system of clamping is to begin at one end and to follow with the necks in one direction only. This is done when the clamp ground is partly occupied by the hacks, so as to render it impossible to commence at the centre. When this system is adopted, the clamping begins with the erection of an end-wall, termed the *upright* and *outside,* which is made to batter very considerably on the outside, but of which the inside face is vertical. As regards dimensions and modes of building, the outside and upright is built in the same way as the ordinary upright, but it has, of course, no live hole under it, the first live hole being provided in the *centre* of the 2nd or 3rd neck. In the style of clamping the necks are all upright. The live holes are placed at every 8th or 9th neck, as in the usual system.

38. We now proceed to describe the principal variations in the methods of clamping practised in different brick-yards.

Paving.—The practice with regard to the paving of burnt bricks is very variable. Some clampers omit it altogether; others pave only where clamping for the first time on a new clamp ground.

Scintles.—When burnt bricks run short, as in building the first clamp on a new ground, the second course is laid with raw bricks. This, however, is a very objectionable practice.

Live Holes.—The live holes are sometimes close-bolted at the sides, to prevent the breeze from the scintles falling into them. This, however, is not often done, and its utility is questionable.

Breeze.—Some clampers put the 7 in. stratum of breeze on the top of the scintles, instead of placing it over the 1st course of raw bricks; very frequently the breeze is dispensed with after the 2 in. stratum, with the exception of the top layer. All clampers, however, agree as to the necessity of having the 7 in., 4 in., and 2 in. layers.

39. The several descriptions of bricks made for the London market, and their relative prices, as given in Lockwood's "Builders' and Contractors' Price Book for 1898," are as under (delivered on the job in London), viz.:—

		£	s.	d.
Stocks	per 1,000	3	0	0
Grizzles	,,	2	15	0
Place	,,	2	0	0
Picked stocks	,,	3	10	0
Red ditto	,,	3	10	0
Best malm facings	,,	4	0	0
Seconds ditto	,,	3	15	0
White Suffolk facings	,,	4	10	0
Seconds ditto	,,	4	0	0
Cutters ditto	,,	7	0	0
Fareham red facings	,,	4	17	0
,, rubbers	,,	6	10	0
Bracknell machine-made facings	,,	3	2	0
,, hand-made ditto	,,	3	7	0

The prices of the various kinds of fire-bricks will be found at page 18.

The bricks commonly sold are known by the following terms:

Cutters.—These are the softest, and are used for gauged arches and other rubbed work.

Malms.—These are the best building bricks, and are only used in the best descriptions of brickwork; colour yellow.

Seconds.—These are sorted from the best qualities, and are much used for the fronts of buildings of a superior class.

Paviours.—These are excellent building bricks, being sound, hard, well shaped, and of good colour. They must not be confounded with paving bricks, having nothing in common with them but their name.

Pickings.—These are good bricks, but soft, and inferior to the best paviours.

Rough Paviours.—These are the roughest pickings from the paviours.

Washed Stocks.—These are the bricks commonly used for ordinary brickwork, and are the worst description of malms.

Grey Stocks.—These are good bricks, but of irregular colour, and are not suited for face work.

Rough Stocks.—These are, as their name implies, very rough as regards shape and colour, and not suited for good work, although hard and sound.

Grizzles.—These are somewhat tender, and only fit for inside work.

Place Bricks.—These are only fit for common purposes, and should not be used for permanent erections.

Shuffs.—These are unsound and *shuffy*—that is, full of shakes.

Burrs or Clinkers.—These are only used for making artificial rockwork for cascades or gardens, &c.

Bats.—These are merely refuse.

It may be here observed, that at the brickworks round London the bricks made are usually in the form of regular parallelopipedons, 9 in. long, 4½ in. wide, and 3 in. thick. If in the execution of a piece of brickwork, bricks of other shapes are required, it was formerly the practice, and still sometimes is, for the bricklayer to cut the ordinary bricks to the required shape. This practice, so destructive to sound bond and good work, cannot be too strongly reprehended;* especially now that the manufacture is free from the trammels of the excise there can be no excuse for not making bricks of a great variety of shapes for various purposes.

40. *Brickmaking at Cheshunt.*—In the "Illustrations of Arts and Manufactures," by Mr. Arthur Aikin, is a valuable paper on pottery and brickmaking, the perusal of which is strongly recommended to the reader. The following notice is there given of the Cheshunt bricks:—"At Cheshunt, in Hertfordshire, is a bed of malm earth of the finest quality, no less than 25 ft. in depth; from this are made the best small kiln-burnt bricks, called paviers." Not having an opportunity of personally examining the Cheshunt works, the author requested Mr. B. P. Stockman to do so, and, in reply, received the following communication, from which it appears that kiln burning has been now disused for some time at Cheshunt; clamping being now generally adopted:—

"There are no bricks now made near London of natural malm; the once well-known bed at Grays in Essex has been exhausted some years. No one can inform me of any bed of natural malm except that at Cheshunt, and I was told, previous to my going there, that I should not find the works conducted as I had been led to expect from your letter.

"There are only two brickmakers at Cheshunt, and, from going over their works, I am able to vouch for the accuracy of the following particulars.

---

* The brick columns, whose failure caused the frightful accident which occurred in January, A.D. 1848, during the erection of the new buildings at the Euston Station of the North Western Railway, were built in this way. The additional cost of bricks made expressly for the work, of such forms as would have bonded properly together without any cutting, would have been very trifling.

"There is a bed of natural malm, and a bed close to it of ordinary brick-earth, which also contains malm. When they make malms, which they were not doing at the time of my visit, they do not use the natural malm earth by itself, but wash and mix chalk with it, and I am told that they *never* have made malms without adding chalk to the natural earth, although the proportion is small compared to that required for the other bed from which they also make malms. The earth is soiled with ashes precisely in the same way as in the London works, and turned over and pugged in the same kind of pug-mill. The bricks are hacked and *clamped*, as in London, and there are *none* burnt in kilns, nor have been for many years. There are no kilns on the ground, and no kiln burning of any description, though in former years there used to be kilns for bricks and tiles, and also for glazed ware.

"The bricks made at Cheshunt are very superior to the London bricks; in fact, the stock made there is really a kind of malm brick, and the malms themselves, as you may suppose, are perfection. I examined the brick-earth from both pits, and saw the several processes of moulding, hacking, scintling, and clamping going on. The names of the different qualities are the same as in London; but, as regards quality, some of the common descriptions are equal to the London malms, and I believe the shuffs would be sold for malms in London."

41. Brickmaking is carried on to a great extent all round the metropolis, but the principal brick-fields are situated north of the Thames.

III. COST OF MANUFACTURE.

42. We propose to consider the cost of manufacture under three heads, viz.:—

1. Materials and fuel.
2. Machinery and tools.
3. Labour.

I. MATERIALS AND FUEL.

43. *Clay.*—The cost of brick-earth must depend very much on the circumstances of the locality, but it is usually considered to be worth 2*s.* 6*d.* per 1,000 bricks, exclusive of getting.

44. *Chalk.*—The cost of chalk is trifling where the works have the advantage of water carriage, as it can be brought to the canal wharfs round London at 2*s.* 10*d.* per ton. To this must be added the cartage, which, in some cases, must be a serious expense.

45. *Sand.*—The above remarks apply to the moulding sand; which is brought from the bed of the Thames, near Woolwich, in barges to the canal wharfs at 2*s.* per ton, a ton being about 1¼ cubic yard. To this must be added cartage, and labour in drying the sand to make it fit for use.

It is difficult to say what quantity of sand is used per 1,000 bricks, but the cost may be taken approximately at from 6*d.* to 8*d.* per 1,000 bricks.

46. *Breeze.*—The quantity of breeze required varies according to circumstances; the proportion may be taken to range from 12 to 20 chaldrons per 100,000 bricks. The cost of breeze may be taken at about 4*s.* 6*d.*

per chaldron. It may here be mentioned, that in London stringent regulations are in force to prevent householders from making use of their domestic ashes, which are collected by parties who contract with the parish authorities for this privilege.

In the Midland Counties the domestic ashes are generally used for manure, the ashes being thrown into the cesspools, an arrangement which would not be permitted in the metropolis. This mode of disposing of the domestic ashes completely prevents the use of breeze in the manufacture of bricks in the district where it is practised.

47. *Soil.*—The cost of soiling cannot be very accurately ascertained. The quantity of soil required depends much on the quality of the brick-earth; 35 chaldrons per 100,000 bricks may be considered a fair average. The cost per chaldron may be taken at 3*s.* to 4*s.* To this must be added the cost of barrowing to the clay heap, 14*s.* to 15*s.* per 100,000 bricks.

48. *Coals and Wood.*—The quantity of faggots required will depend on the number of live holes. This item of expense is very trifling, say 2*s.* per 100,000 for faggots and coals to light the clamp.

49. *Water.*—The water required for the washing-mills is pumped into the troughs as before described, and as shown in the drawings of the washing-mills, fig. 7. That which is used in tempering the clay is brought in buckets from the nearest pond on the works. In some yards the supply is drawn from wells by the contrivance known in the East as a shadoof, and in use at the present day in Germany, and throughout Russia. This simple contrivance is described at page 3 of Mr. Glynn's "Rudimentary Treatise on the Construction of Cranes and Machinery," and the reader is there-

fore referred to the description and wood-cut there given.

It may, however, be worth while to remark, that there is scarcely any difference between the ancient *shadoof* used in Egypt in the time of the Israelitish bondage and that in common use at Edmonton and other places near London, in our own time.

It is impossible to make any calculation as to the proportionate cost of the necessary supply of water to a brickfield, as it forms a portion of the cost of tempering, and cannot be separated from it.

II. MACHINERY AND TOOLS.

50. The average cost of the machinery and tools required in a London brickfield is about as follows:

		£	s.	d.
Chalk and clay mills, together	£60 to	70	0	0
Pug-mill		12	0	0
Cuckhold	5s. to	0	6	0
For each moulder are required—				
1 moulding stool, complete, at		1	1	0
1 mould ,,		0	10	6
3 sets of pallets, 26 in each set	at 9s.	1	7	0
3 bearing-off barrows	at 20s.	3	0	0

In addition to the above are required, a few planks, shovels, barrows, buckets, sieves, and other articles, the aggregate cost of which it is impossible to estimate.

No buildings are required for the actual manufacture. It is, however, usual for the foreman, or "moulder," to live at the field. Stabling may be required or not, according to circumstances and locality.

III. LABOUR.

51. The present cost of labour, &c., near London, may be taken as follows:—

	Per 1,000 bricks.		
	£	s.	d.
Rent of field	0	0	6
Ashes	0	2	0
Removing top mould	0	0	2
Digging earth	0	0	7
Soiling and turning earth	0	0	6
Chalk and expense of washing	0	1	4
Moulding	0	5	6
Horse grinding earth	0	0	6
Sand	0	0	6
Cover boards	0	0	2
Setting	0	1	10
Bolting, sorting, &c.	0	0	3
Loading	0	0	6
Implements, &c.	0	0	6
Superintendence	0	0	6
Interest on capital	0	1	0
Royalty	0	2	6
Bad debts	0	1	0
Preparing hacks, obtaining water, making roads, coals and wood in burning, materials for building sand-houses, and office expenses	0	2	0
	1	1	10

NOTE.—The above prices were carefully prepared for the last edition of this work, but owing to recent advances in the rates of wages are at the present time no doubt low; it is extremely difficult to obtain details, as, owing to the great demand, brickmakers have advanced their selling prices out of all proportion to the cost of production, and are naturally reticent in giving information.

AMERICAN OPINION ON ENGLISH BRICKMAKING.

The following remarks, by a recent American writer,* will not be without interest:—

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* C. T. Davis, in "A Practical Treatise on the Manufacture of Bricks, Tiles, Terra-Cotta, &c."

"English bricks are larger than those commonly made in the United States, being usually 9 inches long, $4\frac{1}{2}$ wide, and $2\frac{1}{4}$ thick, after burning, but they are not so strong, and are generally of an inferior quality.

"In fact, those made by the London brick-makers are of the weakest sort, caused partly by the nature of the clay used, but principally from the habit of mixing ashes in large quantities with the clay; as the domestic ashes which they use contain a large quantity of unburned coal, which is reduced to ashes in the process of firing, leaving the brick very porous, greatly weakened, and generally shaky. This system is very undesirable, for two reasons: first, it is certainly injurious to the health of those who live in the neighbourhood of the stacks, as refuse, frequently mixed with decomposed animal and vegetable matter, the contents of dust holes, is used in the process of burning; second, the matter of this kind which is sifted and mixed with the clay, pieces of bone, and other substances of a similarly objectionable character, not being infrequent, is certain to yield an undesirable excrescence arising from nitrogenous substances.

"The most nauseating fumes often arise from the stacks of bricks made and burned in this manner, which tend to make the immediate neighbourhood of one of these clamps anything but a desirable place for a residence, especially during the hot, close months of midsummer, which is the period during which the greater amount of this kind of brick burning is done.

* * * * *

"This manner of burning bricks should not be confounded with the process called 'clamping' so common, and practised largely both in the United States and in some parts of Great Britain remote from London, which is usually a method of burning bricks by placing them in a temporary kiln, the walls of which are generally built of 'green' or unburned bricks.

REFERENCE TO ILLUSTRATIONS ACCOMPANYING THE FOREGOING ACCOUNT OF BRICKMAKING IN THE VICINITY OF LONDON.

52.—Fig. 1. *General Plan of a Brickwork.*

(Scale 40 ft. to an inch.)

A. The chalk-mill.
B. The clay washing-mill.
C. The pump.
D. The shoot to the brick-earth.
E. The brick-earth turned over in readiness to receive the malm.
F. The pug-mill.
G. The moulding stool.
H. The hack ground.
K.K. Clamps.

53. *The Chalk-mill.*

Figs. 2 and 3. Section and Plan. (Scale 10 ft. to an inch.)
a.a. Grinding-wheels.
b. Inlet from pump.
c. Outlet to clay washing-mill.
Details. (Scale 5 ft. to an inch.)
Fig. 4. Grinding-wheel.
Fig. 5. Mode of connecting the axle-tree of the grinding-wheels with the centre shaft.

The mill consists of a circular trough lined with brickwork, and furnished with a pair of heavy wheels with spiked tires, which, being drawn round by horses, crush and grind the chalk until it is reduced to a pulp. The wheels are shown in detail in fig. 4. It is necessary that they should accommodate themselves to the level of the chalk in the trough, and to effect this, the framing of which the axle-tree forms a part is secured to the centre shaft by a staple, as shown in fig. 5, which allows the whole of the timbering to rise or fall, as may be requisite. The centre shaft is a bar of iron, steadied by being built up in a mass of brickwork. The yoke beams are kept at the proper height, and their weight supported by common light chaise wheels, about 2 ft. 6 in. diameter, which run on the outside of the horse track. The mill represented in these engravings is mounted for two horses; many mills, however, have but one.

54. *The Clay-washing Mill.*

Figs. 6 and 7. Plan and elevation. (Scale 10 ft. to an inch.)
a. The inlet from the chalk-mill.
b. The outlet to the shoot.
c.c. The harrows.
d.d. The cutters.
e. The pump.
Details. (Scale 1¼ in. to 5 ft.)
Fig. 8. The cutters.
Fig. 9. The outlet to the shoot, and the strainer.
Fig. 10. The strainer.

The mill consists of a circular trough of larger dimensions than that of the chalk-mill, also lined with brickwork, and furnished with a two-horse gin, to which are attached knives and harrows, which, in their passage round the trough, cut up the clay and incorporate it with the pulp from the chalk-mill. The framing of the gin is very simple, and requires no description. The knives, or cutters, are placed in two sets, four in each. They are fixed in an upright position, and steadied to their work by chains, and by being bolted together with bolts passing through tubular distance pieces, as shown in fig. 8. The knives cut the clay and clear the way for the harrows, which are similar to those used for agricultural purposes, and are merely suspended by chains from the timber framing. The pump is worked by the horizontal wheel F, fig. 7, which is provided with friction rollers on its rim, for the purpose of lifting the lever G, which raises the lever of the pump by means of the spindle H. The outlet to the shoots is simply a square trunk made of 2 in. plank. It is furnished with a brass grating, or strainer, shown in fig. 10. The bars are $\frac{3}{4}$ in. wide, and $\frac{1}{4}$ in. apart, so that even small stones will not pass through. This grating is fixed in grooves, so that it can be lifted out of its place by the handles, when required.

55. *The Pug-mill.*

Fig. 11. Elevation. (Scale 4 ft. to an inch.)
- *a.* The yoke arm.
- *b.* The opening for the ejectment of the earth when *ground.*
- *c.* The brick-earth surrounding the mill, on which is an inclined barrow road to the top of the mill.

Fig. 12. Section. (Scale 2 ft. to an inch.)
- *a.a.* Force knives. These are not provided with cross knives, their purpose being merely to force the earth downwards and out at the ejectment hole.

56.—Fig. 13. *Isometrical View of the Moulding Stool.* (Scale 4 ft. to an inch.)

- *a.* The lump of ground earth from the pug-mill.
- *b.* The moulder's sand.
- *c.* The clot-moulder's sand.
- *d.* The bottom of the mould, termed the *stock-board.*
- *e.* The water-tub.
- *f.* The *page,* which is formed of two rods of $\frac{3}{8}$ths of an inch round or square iron, nailed down at each end to the wooden rails or sleepers on which they rest. The use of the page is to slide the new bricks, with their pallets, away from the moulder with facility.
- *g.* The pallets in their proper position for use.
- *h.* A newly-made brick just slidden from the moulder, and ready for the taking-off boy.
- *k.* The moulder's place.
- *m.* The clot-moulder's place.
- *n.* The taking-off boy's place.
- *o.* The *cuckhold,* a concave shovel used for cutting off the ground-earth as it is ejected from the pug-mill.

75.—Fig. 14. *Isometrical View of the Brick Mould, with its detached bottom or Stock-board.* (Scale 2 in. to a foot.)

a.a.a. The iron pegs on which the mould rests during the operation of moulding. They are driven into the stool in the positions shown in the drawing; their height from the stool regulates the thickness of the brick. The mould is lined throughout with sheet-iron, which is turned over the edges of the mould at the top and bottom.

58.—Fig. 15. *The Hack Barrow*—loaded. (Scale 2 ft. to an inch.)

Fig. 16. *The hack barrow*—unloaded. (Scale 2 ft. to an inch.)

59. *The Clamp.*

Fig. 17. Transverse section (parallel to necks). (Scale 10 ft. to an inch.)

Fig. 18. Longitudinal ditto ditto ditto.
a. The upright.
b.b. Close bolts.
c. Live hole.
d. Bestowing.
Details. (Scale 2 ft. to an inch.)

Fig. 19. Plan of the lower course of scintles.

Fig. 20. Plan of the upper course of scintles.
. The live hole.

It should be understood that the directions of the scintles, as well as that of the paving below it, are changed for every neck, so as to correspond with the upper work, as shown in the figures.

Fig. 21. Detail of the end of the upright, showing the paving, the scintling, the live hole, and the 7 in., 4 in., and 2 in. courses of breeze.

CHAPTER VI.

LONDON TILERIES.

1. The general term, "Tile Manufacture," is so comprehensive, that it would be impossible, within the limits of a little volume like the present, to give anything like a complete account of the manufacture of the different

articles made at a large tilery; we only propose, therefore, in the present chapter, to give a succinct account of the manufacture of pantiles, as carried on at the London tileries, which will serve to give the reader a general idea of the nature of the processes employed in tile-making. It must, however, be borne in mind, that although the principle of proceeding is the same in each case, there are no two articles made exactly in the same way, the moulding and subsequent processes being carried on in a different manner, and with different tools and implements, for every description of article.

The manufacture of plain tiles and drain tiles has already been described in Chap. IV., to which the reader is referred, as also to the supplementary chapter at page 220.

2. The following is a list of the principal articles made at the London tileries:—

Oven tiles.
10-in. paving tiles.
Foot ditto.
Plain tiles.
Pantiles.
Ridge tiles.
Hip tiles.
Drain tiles.
Kiln bricks.
Fire bricks.
Paving bricks.
Circulars (for setting coppers, &c.)
Column bricks (for forming columns).
Chimney-pots.
Garden-pots.
Drain pipes.

And anything required to order.

For all these articles (excepting fire bricks) the same clay is employed (mixed, for the making of paving tiles, oven tiles,* kiln bricks, paving bricks, circular bricks, and column bricks, with a certain quantity of loam), and they are all burnt in the same kiln, the fire bricks included; but each different article presents some peculiarity in the processes intervening between the tempering and the burning, having its separate moulding.

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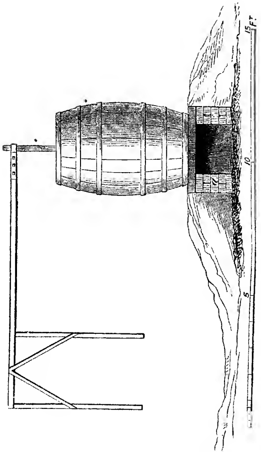
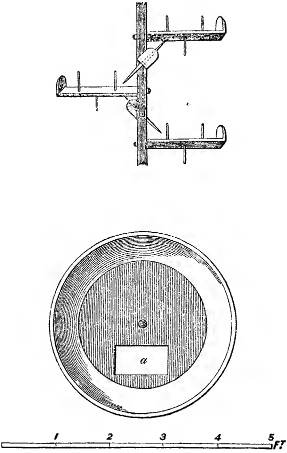
* For oven tiles the stuff must be of superior quality.

Fig. 1.



stool, frames, strike, &c., and being stacked and dried differently. The details of these differences, however (even would our limits allow us to describe them), would scarcely be suited to the pages of a rudimentary work intended for popular reading.

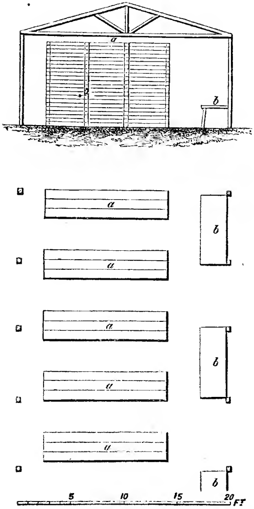
Figs. 2 and 3.



BUILDINGS AND PLANT.

3. *Pug-mill.*—The pug-mill used in tile making for pugging, or, as it is termed, *grinding* the clay, differs considerably from that used in brick-making. The tub, instead of being conical, is made to taper at both ends,

Fig. 5.



and the ejectment hole is at the bottom instead of in the front, as in the brick pug-mill.

The knives, also, are made in a superior manner.

Fig. 4.

Fig. 7.

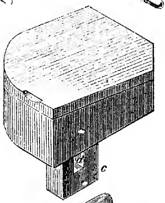


Fig. 8.

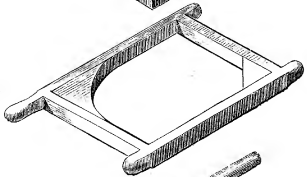
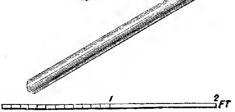


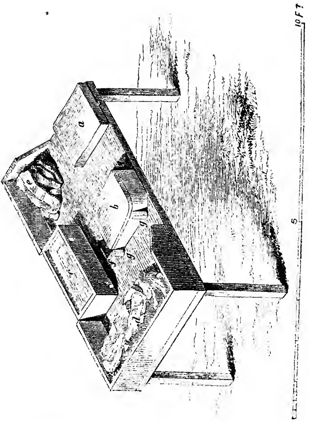
Fig. 9.



The mill is provided with force knives without cross knives at top and bottom. See figures 1, 2, and 3.

The pug-mill is placed under cover in a shed called the *grinding* shed.

Fig. 6.

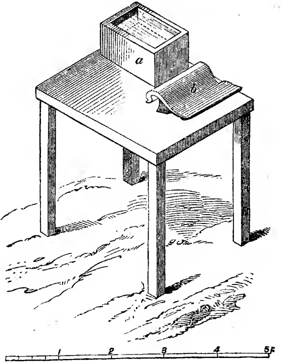


4. *The Sling*, fig. 4, is simply a piece of thin wire with two handles, used for cutting the clay.

5. *Moulding Shed.*—Tiles are made under cover in sheds about 7 yards wide, the length of the shed depending on the number of moulding tables, the area allotted to each table being about 7 yards in length by 4 yards in breadth.

The moulding tables are placed against one side of

Fig. 10.



the shed, and the remainder of the area is occupied by the *blocks* or drying-shelves; every shelf being formed with three 1 in. planks placed edge to edge, and separated from each other by bricks placed edgewise at the end of the planks, as well as at intermediate points, each block containing about 14 shelves, and thus measuring 12 ft. long by 2 ft. 8 in. wide, and about 7 ft. high. A passage way, 3 ft. wide, is left round the blocks, to give free access to every part of them.

These details will be understood by reference to fig. 5.

6. *The Pantile Table*, or moulding table, is shown in

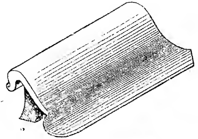


Fig. 11.

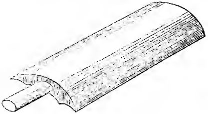


Fig. 12.

Fig. 13.

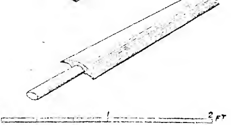
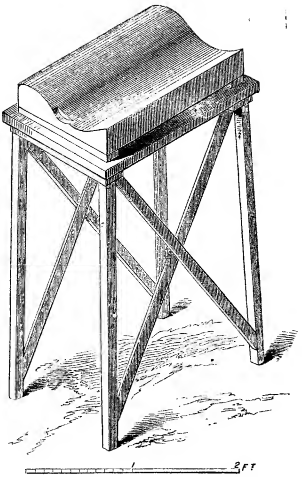


Fig. 15.

fig. 6. It is furnished with a *trug* or trough, in which the moulder dips his hands when moulding, and with a *block and stock-board,* on which the tile mould is placed in the operation of moulding.

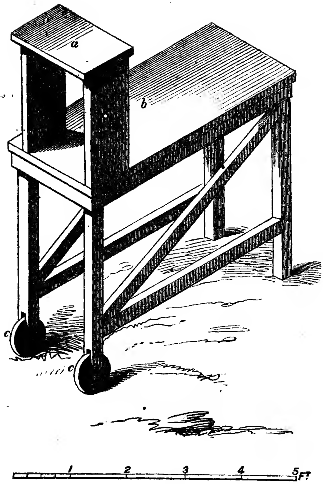
7. ***The Block and Stock-board*** is shown in fig. 7. The two form one piece, which rests on the moulding table, and is firmly keyed to it by means of a tenon on

Fig. 13.



the under side of the block passing through a mortice in the table. Four pegs, driven into the table at the corners of the block and stock-board, serve as a support for the mould and regulate the thickness of the tile, $\frac{3}{8}$ in. being the thickness of a pantile.

Fig. 14.

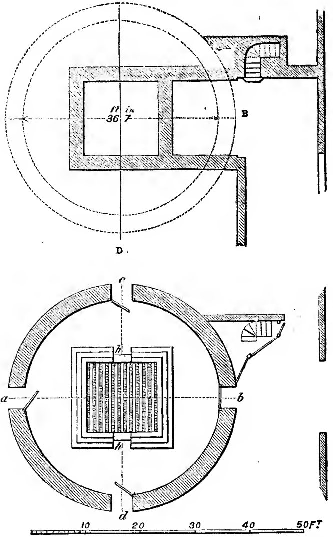


8. *The Tile Mould* is shown in fig. 8, and requires no particular description.

9. *The Roll*, fig. 9, is merely a round roller of a particular size, as shown by the scale, and is used for striking a smooth surface to the tile.

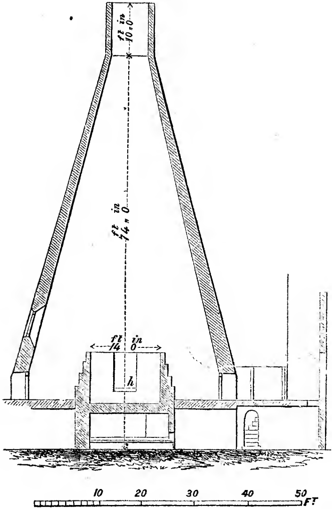
10. *The Washing-off Table*, fig. 10, is a stand with

Figs. 17 and 18.



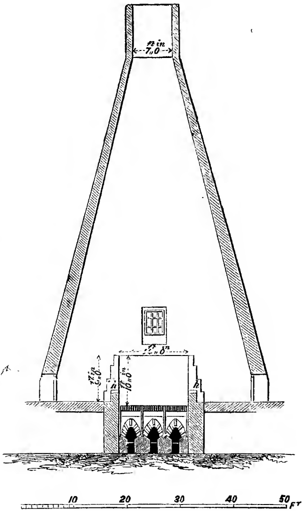
a water trough and a frame called the ***Washing-off Frame***, see fig. 11, on which, when moulded, the tile is

Fig. 19.



washed into a curved form. The washing-off table is placed at the left hand end of the pantile table, and near the block.

Fig. 20.



11. *The Splayer,* fig. 12, is an instrument on which the tile is removed from the washing-off frame to the block.

12. *The Thwacking Frame,* fig. 13, is a frame on

Fig. 21.

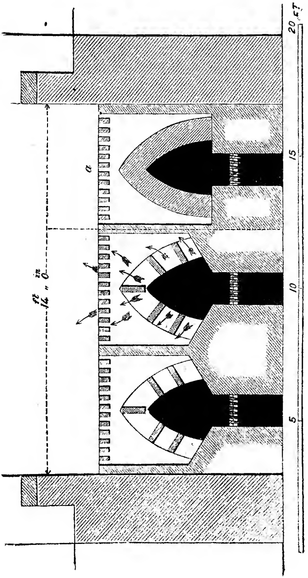
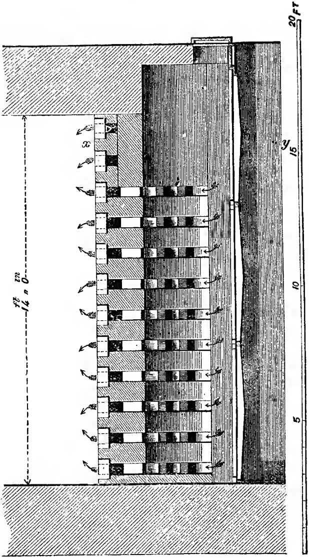


Fig. 22.



for saying that the gibbons, "without having been taught, can walk or run upright with tolerable quickness, though they move awkwardly, and much less securely than man." The Quarterly Reviewer says, "This is a little misleading, inasmuch as it is not stated that this upright progression is effected by placing the enormously long arms behind the head, or holding them out backwards as a balance in progression."

Now, before carping at a small statement like this, the Quarterly Reviewer should have made sure that he was quite right. But he happens to be quite wrong. I suspect he got his notion of the manner in which a gibbon walks from a citation in "Man's Place in Nature." But at that time I had not seen a gibbon walk. Since then I have, and I can testify that nothing can be more precise than Mr. Darwin's statement. The gibbon I saw walked without either putting his arms behind his head or holding them out backwards. All he did was to touch the ground with the outstretched fingers of his long arms now and then, just as one sees a man who carries a stick, but does not need one, touch the ground with it as he walks along.

Again, a large number of the objections brought forward by Mr. Mivart and the Quarterly Reviewer apply to evolution in general, quite as much as to the particular form of that doctrine advocated by Mr. Darwin; or, to their notions of Mr. Darwin's views and not to what they really are. An excelwhich the tile, when half dry, is *thwacked* or beaten with a *thwacker* (fig. 15), to correct any warping which may have taken place whilst drying in the block.

When thwacking those tiles taken from the bottom of the block, the thwacking frame is placed upon the *Thwacking Stool,* fig. 13; but when the tiles to be thwacked are at the top of the block, the thwacking frame is placed upon the *Thwacking Horse,* fig. 14, which brings it conveniently to their level.

The *Thwacking Knife,* fig. 16, is used for trimming the wing of the pantile immediately after thwacking.

13. *The Tile Kiln,* figs. 17, 18, 19, 20, 21, and 22, consists of a kiln with arched furnaces, enclosed in a conical building called a dome. The arrangement of the whole building will be clearly understood by reference to the figures, and to the detailed description at the end of this chapter.

PROCESS OF MANUFACTURE.

14. *Clay-getting and Weathering.*—The clay used for making tiles is purer and stronger than that used for making bricks, and consequently requires more care in its treatment.

When the clay is too strong, it is mixed with sand before passing it through the pug-mill, but this is not often required.

The weathering of the clay is performed by spreading it out in thin layers, about 2 in. thick, during the winter, and each layer is allowed to receive the benefit of at least one night's frost before the succeeding layer is placed over it. Sometimes the clay is spread out in the summer to be scorched by the sun, which effects the weathering equally well. The greater the heat, or the sharper the frost, the thicker may be the layers, but 4 in. is the maximum thickness.

The object of the process of weathering is, to open the pores of the clay, and to separate the particles, that it may absorb water more readily in the subsequent process of mellowing.

The clay thus weathered is thrown into pits, where it is covered with water, and left for a considerable time to mellow, or ripen.

15. *Tempering.*—The process of tempering is performed simply by passing the clay through the pug-mill. If the clay be very foul, that is, full of stones, it is *slung* before using, and passed a second time through the mill. For chimney-pots and similar articles, the clay is slung either once or twice, and pugged, or, as it is called, *ground*, twice or thrice, according to the nature of the clay, and the purpose to which it is to be applied.

16. *Slinging.*—The operation of slinging is as follows: as the clay issues from the ejectment hole of the pug-mill, it is cut into lengths of about 2 ft., with a sling. These lumps are taken by the slingers and cut up into slices, not exceeding $\frac{3}{4}$ in. in thickness, during which operation most of the stones fall out, and those which remain are picked out by hand. The clay thus freed from stones is once more ground, and is then ready for the moulder.

(N.B. In some parts of England the clay is freed from stones by sifting, and the tempering is performed by treading; this part of the work being done by boys, who tread in a spiral track, so as to subject each portion of the mass to a uniform amount of kneading.)

17. *Moulding.*—The clay, as it issues from the mill, is cut into lumps, called *pieces*, which are stacked on a rough bench in the grinding shed. A labourer cuts

these lumps in half, each half being called a *half-piece,* and wheels these half-pieces one by one to the pantile table.

A rough-moulder, generally a boy, takes the half-piece and *squares* it up, that is, beats it up into a slab near the shape of the mould, and about 4 in. thick, from which he cuts off a thin slice, the size of a tile, and passes it to the moulder.

The moulder, having sanded his stock-board, and placed his mould on the four pegs which regulate the thickness of the tile, takes the slice of clay from the rough-moulder, and puts it into the mould. He then, with very wet hands, smooths the surface, cutting off the superfluous clay with his hands, in long pieces, called strippings, which are thrown to a corner of the table. This done, he strikes the surface level with the roll; and turning the tile out of the mould on the washing-off frame, with very wet hands washes it into a curved shape. He then strikes it smartly with the splayer, and turns it over on that implement, on which he conveys it to the block, where he deposits the tile with the convex side uppermost, and, the splayer being withdrawn, the tile is left to dry. The button end of the tile is placed inside the block.

18. *Thwacking.*—The tiles remain in the block until they are half dry, when they are taken out one by one, placed on the thwacking frame, and beaten with the thwacker to perfect their shape.

The wing of each tile is then trimmed with the thwacking knife, and the tiles replaced in the block, still with the convex side uppermost; but this time the button end is placed outside. The tiles then remain in the block until ready for kilning.

It should be observed that the tiles flatten slightly whilst in the block, and for this reason the washing-off frame is made a little more convex than the thwacking frame, which corresponds to the permanent form of the tile.

19. *Kilning.*—In setting the kiln, a course of vitrified bricks is laid at the bottom, herring-bone fashion, the bricks being placed 1½ in. apart. On this foundation the tiles are stacked as closely as they will lie, in an upright position, one course above another. As the body of the kiln is filled, the hatchways are bricked up with old bricks, and when the kiln is topped, they are plastered over with loam or clay. The top is then covered with one course of unburnt tiles, placed flat, and lastly, upon these a course of old pantiles is loosely laid.

The fires are lighted on Monday morning, and are not put out until Saturday evening, whatever the articles in the kiln.

The fuel used is coal, and the quantity consumed at each burning about eight tons. This, however, varies with the kind of articles to be burnt,—hollow goods, as chimney-pots, garden-pots, &c., requiring less than more solid articles. Foot tiles, oven ditto, and 10-in. ditto, are stacked in the kiln the same way as paving bricks. The covering on the top of the kiln varies in thickness, according to the sort of goods to be fired.

COST OF MANUFACTURE.

20. From the manufacture of tiles being carried on under cover, the establishment of a large tile-work involves a considerable amount of capital. The kiln used in London is very costly, such a one as we have

shown in figs. 17 to 22 costing in its erection no less than £2,000.

The cost of making pantiles by machinery is about as follows, per 1,000 :—

	£	s.	d.
Clay—this is usually included in the rent, but, if purchased separately, may be taken at 2*s.* 6*d.* per yard cube—2¼ yards cube make 1,000 pantiles . . .	0	5	7½
Weathering clay	0	5	0
Mellowing ditto, and grinding once	0	2	0
Add for horsing the pug-mill	0	1	6
If slung and ground a second time, add	0	2	0
Moulding, including all labour in fetching clay from mill, moulding, washing, blocking, thwacking, and blocking second time	0	10	0
Setting and drawing kiln	0	3	0
Burning	0	12	6
Cost of making	2	1	7½
Rent, repairs, breakage, contingencies, and profit . .	1	8	4½
Selling price per 1,000 . . .	3	10	0

21. The following are the ordinary prices, in 1898, for a variety of articles, which will give an idea of the comparative amount of labour bestowed upon them :—

		£	s.	d.
Plain tiles	per 1,000	2	12	0
Rich dark red tiles . . .	,,	2	15	0
Strawberry colour tiles . . .	,,	2	16	0
Broseley red buff or brindled tiles .	,,	3	7	6
Ditto ornamental tiles . . .	,,	3	10	0
Corrugated tiles	,,	3	10	0
Pan tiles	,,	3	10	0
Hip and valley tiles . . .	per 100	1	5	0
Plain red ridges	each	0	1	0
Ditto blue Staffordshire ditto .	,,	0	0	6

22. The above sketch of the manufacture of pantiles will give the reader a general idea of the processes used in tile-making, but every article presents some peculiarity of manufacture. Plain tiles are dried on flats, called *Place Grounds.* Hip and ridge tiles are washed

and thwacked in a similar manner to pantiles. Drain tiles are only washed. Paving tiles and oven tiles are stricken with a flat strike instead of the roll, and are not washed, but they are thwacked and dressed with a knife.

23. *Description of Illustrations.*

Figs. 1, 2, and 3. The pug-mill.

The pug mill used in tile-making is different from that used in brick-making, as will readily be seen from the figures.

Fig. 1. Elevation of pug-mill. (Scale ¼ in. to the foot.)

Fig. 2. Details of the knives. (Scale ½ in. to the foot.)

These knives are made in a superior manner to those of the brick pug-mills, both as regards strength and fitting. The mill is provided with force knives at top and bottom, which have no cross knives attached to them.

Fig. 3. Cross section of the tub. (Scale ½ in. to the foot.)

a. The ejectment hole, which is at the bottom of the tub, and not at the side, as in the brick pug-mill.

Fig. 4. The sling, or wire knife, used for cutting the clay into lengths as it issues from the pug-mill, and also for freeing the clay from stones (slinging).

Fig. 5. The tile shed, shown in plan and section. (Scale 10 ft. to the inch.)

a.a.a. The blocks, which consist of a series of shelves, on which the tiles are placed to dry. Each shelf is formed of three 11-inch planks. The shelves are 4½ in. apart, and are spaced off from each other by bricks laid edgewise, at the end of the block, and also midway between these points.

b.b.b. The moulding tables.

Fig. 6. The pantile table, used for moulding pantiles. (Scale ⅜ in. to the foot.)

a. The half-piece squared up.
b. The block and stock-board.
c. The trug or trough.
d. The moulder's sand.
e. The strippings.
f. A hole in the table for sweepings to drop through.
g.g.g. The pegs on which the mould is placed. There are four of these pegs; viz., one at each corner of the block and stock-board; and the distance to which they are driven below the top of the stock-board, determines the thickness of the tile.

Fig. 7. The block and stock-board. (Scale 1 in. to the foot.)

c. A tenon, which drops into a mortice in the table.
d. A mortice in *c*, by which the block and stock-board is keyed tightly to the table.

Fig. 8. The pantile mould. (Scale 1 in. to the foot.)

Fig. 9. The roll. (Scale 1 in. to the foot.)

Fig. 10. The washing-off table. (Scale ½ in. to the foot.)

a. The washing-off trug.

b. The washing-off frame.

Fig. 11. The washing-off frame. (Scale 1 in. to the foot.)

Fig. 12. The splayer. (Scale 1 in. to the foot.)

Fig. 13. The thwacking frame placed on the thwacking stool. (Scale 1 in. to the foot.)

Fig. 14. The thwacking horse, on which the thwacking frame is placed for thwacking those tiles at the top of the blocks. (Scale ½ in. to the foot.)

a. The table on which the thwacking frame is placed.

b. The place where the thwacker stands to thwack.

c.c. Two wheels to facilitate the moving of the horse from place to place when required.

Fig. 15. The thwacker. (Scale 1 in. to the foot.)

Fig. 16. The thwacking knife. (Scale 1 in. to the foot.) This is simply an iron blade, with a piece cut out exactly to the intended profile of the wing of the pantile, which is trimmed with it immediately after thwacking.

Figs. 17 to 22. The tile kiln.

(N.B. The whole of the furnace and body of the kiln is constructed of fire brick.)

Fig. 17. Plan of the kiln, taken through the body. (Scale 20 feet to the inch.)

h.h. The hatchways.

Fig. 18. Plan of the basement, to the same scale, showing the entrance to the vaults.

Fig. 19.* Section through the centre of the kiln, in the direction of the line *a b*, fig. 18. (Same scale.)

Fig. 20. Section through the centre of the kiln, in the direction of the line *c d*. (Same scale.)

Fig. 21. Transverse section of the furnaces. (Scale ¼ in. to the foot.) The section marked *a* is taken through the throat of the furnace, on the line marked *x y*, in fig. 22.

Fig. 22. Longitudinal section of the furnaces. (Same scale.) The arrows in each of the above figures show the direction of the flues.

CHAPTER VII.

ON THE MANUFACTURE OF ENCAUSTIC TILES.

1. The highly-decorative pavements of the mediæval ages, principally to be found in our old ecclesiastical structures, which often shared the fate of many beautiful

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* This cut and the following are not quite accurate, the sides of the dome not being straight, as shown in the engraving, but slightly convex.

details of architectural ornament, by being made to give way to what rustic churchwardens, and others of equal taste and discernment, deemed *improvements*—after attracting the attention of the antiquary for centuries, have at length excited some interest amongst the practical minds of these our stirring business times. About thirty years since a patent was obtained by Mr. S. Wright, of the Staffordshire Potteries, for the revival of this interesting branch of art, for such it may be truly called. As might have been expected, many difficulties beset the patentee, and for some years nothing was produced equal to the old specimens. But still a beginning was made that promised success when skill and capital, and a determination to succeed, should be brought to bear upon the subject. And these were not long wanting, as the patent ultimately passed into the hands of a gentleman undeterred by difficulties or previous failures, and who expressed his intention to make encaustic tiles, such as would secure the public approbation, even if each one cost him a guinea! This is the spirit that has achieved such surprising results in our manufactures generally, within a comparatively brief period; and no wonder that in this, as in most other instances, success has been the satisfactory result. We need scarcely say that the gentleman referred to is Mr. Herbert Minton, who, with untiring industry, collected the best specimens of old tiles that could be found in this country, and by a succession of experiments overcame the obstacles that had retarded the success of the undertaking.

2. The chief of these obstacles was, to discover clays of different colours that could be made to amalgamate in such a way as to contract or shrink equally during the processes of drying and firing; and until this was effected, a perfect tile of several colours could not be produced,

sundry unsightly cracks appearing on the inlaid parts of the surface. It will be unnecessary to speak of the present state of perfection to which these beautiful tiles have been brought, further than to observe that they are yearly becoming more appreciated, both on the score of durability and ornament; and there can scarcely be a doubt that, very soon, no ecclesiastical building, having any pretensions to architectural superiority, will be considered to be complete in its decorations without them. By way of information, we may add, that not only copies of old tiles are manufactured, but every variety of design suitable for the character of the building they are intended for are supplied. Indeed, almost any pattern can be produced with facility; and we have seen some of the arms of our nobility and gentry so finely executed, that the uninitiated might be pardoned for mistaking these inlaid clays for the highly-finished and elaborate work of the pencil. In many instances they have been adopted as a substitute for oil-cloth in the halls and passages of the mansions of our nobility, being considered far more beautiful, and, from their durability, more economical also, in the long run.

3. We will now take a peep into the interior of Messrs. Minton and Co.'s manufactory.* We must first notice, that the clays of which the tiles are composed are obtained in the immediate neighbourhood—the ordinary marl producing a good buff colour when fired; another kind a warm red; black is produced by staining with manganese; blue with cobalt, &c. With the native clays there is a slight admixture of Cornwall stone and clay, and flint from Kent, &c. The whole are subjected to a variety of washings and purifications—the clay in-

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* Further details will be found in "Tomlinson's Cyclopædia"—article, Pottery and Porcelain.

tended for the surface, especially—and passed through fine lawn sieves in a liquid, or "slip" state, as it is technically termed. In this state it is conveyed to the slip-kiln, or rather pumped on it, and boiled, until it is in a plastic state, and fit for use.

4. After the modeller has done his part, the pattern is cast in plaster in relief, and is then placed in a metal frame of the size required; but it should be stated that to produce the ordinary 6-in. square tile, it is modelled 6⅝ in., to allow for shrinkage or contraction, which takes place during drying and firing. The maker then commences his operations. A piece of the fine clay for the surface is flattened out to about a quarter of an inch thick, somewhat after the manner of preparing a pie crust, and this is thrown upon, and pressed upon, the plaster pattern, and receives, of course, a correct indentation, or outline of the design. The metal frame containing the plaster mould is divided horizontally, and after the surface is put in, the upper part of the frame is screwed on, and the maker fills up with clay of a somewhat coarser description, to form the tile of the requisite thickness. The tile is then put under a screw-press to impart the proper degree of solidity.

5. As far as we have gone, the tile is but of one colour; next comes the task of giving the different colours required. Suppose a tile be required of three colours—red, blue, and buff. We will say the surface piece already put in is of a buff colour. The maker provides himself with vessels of a suitable kind, containing—the one the blue, the other the red colour, in a "slip" state, and these he pours into those parts of the indented surface that the drawing or finished tile before him tells him to be correct. These slips cover the surface entirely, and there is now not the slightest appearance of any pattern

or design. After remaining in this state for three days, until the water has evaporated for the most part, the process of scraping or planing the surface commences, which is an operation requiring care, though easily effected by experienced hands. The pattern then makes its appearance, but the colours are scarcely distinguishable the one from the other.

6. The tile is then finished as far as the maker is concerned; and, after remaining in the drying house from 14 to 21 days, according to circumstances, is conveyed to the oven, where it is exposed to an intense degree of heat for about 60 hours. After being drawn from the oven, the tile is finished, except it be that the parties ordering wish the surface glazed, a rapid and easy process, the dipper merely placing the surface in a tub of glaze.

7. Plain self-coloured tiles, such as black, red, chocolate, buff, &c., and also tesseræ, are made of the same material as the encaustic, only that it is dried longer in the kiln, passed through rollers to reduce it to a powder, and is then finely sifted. Presses of great power, made under Prosser's patent, make these tiles. The powdered clay is swept into a recess of the proper size, the screw descends, and, by its immense power, presses the powder into a solid tile, ready for drying and firing. One man can, with ease, make about 500 per day.

8. *Tesseræ.*—The tesseræ made by Messrs. Minton, under Mr. Prosser's patent, are now extensively used for mosaic pavements, for which they are admirably adapted. A few words will suffice to explain the nature of the improvements effected in this branch of art by the introduction of the new material.

The mosaic pavements made by the Romans were formed of small pieces of stone or marble of various colours, bedded one by one in a layer of cement, each of the pieces being levelled with the others as the work proceeded, and on the completion of the work the unavoidable inequalities of surface were corrected by *rubbing* the whole to a plane surface.

This mode of proceeding was attended with many defects. The irregular shapes of the tesseræ caused the cement joints to be of a thickness that greatly injured the effect of the design, whilst the piecemeal way in which the work was laid rendered it very difficult to produce a level surface.

It is not our purpose here to detail the several attempts that have been made during the last few years, with various degrees of success, to produce mosaic pavements, by the use of clay tesseræ, coloured cements, &c.; but it will readily be understood that the principal difficulties to be overcome in the use of solid tesseræ are those arising from irregularity in the shape and size of the several pieces, as well as the great labour and expense attending the laying of such pavements piece by piece.

These difficulties have been entirely overcome by the use of the patent tesseræ, which, being made in steel dies, by the process above described, are perfectly uniform in size, and fit closely together, with an almost imperceptible joint.

The mode in which the tesseræ are used is precisely the reverse of the Roman process, and is as follows:—a coloured design of the intended mosaic having been drawn to scale, after the fashion of a Berlin wool pattern, the pattern is set out full size on a cement floor, perfectly smooth and level, and on this floor the tesseræ are placed close together, the workmen being guided in the arrangement of the colours by the small drawing.

The pieces are then joined together by a layer of cement applied to the upper surface, and in this way they are formed into slabs of convenient size, which, when hard, are ready for use, and can be laid with as much ease as ordinary flagstones. It will at once be understood, that the side of the slabs which is next the floor during the process of manufacture forms the upper side of the finished pavement, the pattern appearing reversed during its formation.

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CHAPTER VIII.

ON THE MANUFACTURE OF BRICKS AND DRAIN PIPES BY MACHINERY.

It is the general opinion that brickmaking by machinery is not economical in small work, since the cost of moulding bears so small a proportion to the total cost. In large engineering works, however, where a contractor requires many millions of bricks in a limited time, for the construction of a tunnel or viaduct, the use of machinery may be desirable. In this chapter we do not, of course, pretend to give descriptions of the various patented and other machines connected with the manufacture of bricks and tiles. Our object, in a work of this kind, being to deal with the principles of the art rather than with a multiplicity of minute details. We may, however, in order to show the great vitality of the trade, quote a few titles of inventions, &c., belonging to the years 1861 and 1862. The patent list displays the strong tendency to invention for making bricks, &c., by machinery. Thus, we have—

Wimball's patent for making bricks, tiles, and drain pipes.

Morrell and Charnley's apparatus for making bricks, tiles, and other articles from plastic materials.

Green and Wright's machinery for the manufacture of plain and ornamental bricks, slabs, tiles, and quarries.

Basford's patent for constructing brick walls, and ornamenting the materials to be used for the same.

Effertz' machinery for making bricks, tiles, &c.

Grimshaw's patent for compressing brick-earth and other materials.

Morris and Radford's patent for the manufacture of fire bricks, blocks, &c.

Poole's patent for making ornamental bricks, tiles, &c.

Newton's machine for making bricks.

Sharp and Balmer's apparatus for the manufacture and drying of bricks.

Grimshaw's patent apparatus, used in drying, pulverising, and compressing clay.

Platt and Richardson's apparatus for making bricks.

Foster's method of rendering bricks impervious to damp.

Smith's patent apparatus for the manufacture of bricks, tiles, &c.

The following description of Oates's brickmaking machine is from Tomlinson's "Cyclopædia of Useful Arts, &c." It was described by Mr. J. E. Clift, of Birmingham, at a meeting of the Institution of Mechanical Engineers, in November, 1859, and the description is printed in the "Proceedings" of that body, and is illustrated by four engraved plates, from which Mr. Tomlinson has compiled the illustrative figure. We do not give this machine as the best, since there are many other well-known machines of merit in use; but we offer it as an example of the mechanical means adopted in this class of inventions.

The present brickmaking machines at work are divided by Mr. Clift into two classes, viz., those that operate on the clay in a moist and plastic state, and those for which the material requires to be dried and ground previous to being moulded. In the former class, the plastic column of clay, having been formed into a continuous length by the operation of a screw, pugging blades, or rollers, is divided into bricks by means of wires moved across, either while the clay is at rest or while in motion, by the wires being moved obliquely at an angle to compensate for the speed at which the clay travels. This wire-cutting requires the clay to be soft, so that the bricks are but little harder than those made by hand, and require a similar drying before being placed in the kiln; and all this renders the expense of manufacture about the same as for hand-made bricks. In the second class of machines, the bricks are compressed in a dry state in the mould; but the processes for drying the clay, and reducing it to a uniform powder, add to the cost of manufacture.

Mr. Oates has got rid of both objections, viz., the difficulty respecting the previous preparation of the clay, and the subsequent drying of the bricks. In his machine the clay is used of such a degree of dryness as to allow of its being mixed up and macerated, and compressed into bricks by a single continuous action, the clay being formed into a continuous column and compressed into the moulds by the action of a revolving vertical screw. The clay requires, in general, no previous preparation beyond that given by the ordinary crushing rollers, and, in some cases, may be put into the machine direct from the pit, unless it contain stones, when it is passed through a pair of rollers. Figs. 2 and 3, when joined at the parts indicated by the dotted lines, form a longitudinal section of the machine, and fig. 1 is a plan of the screw.

Fig. 1.

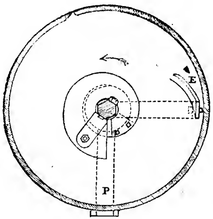
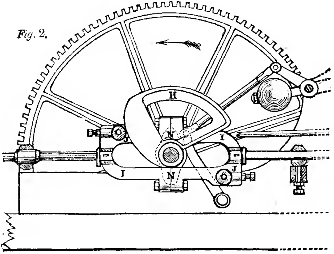
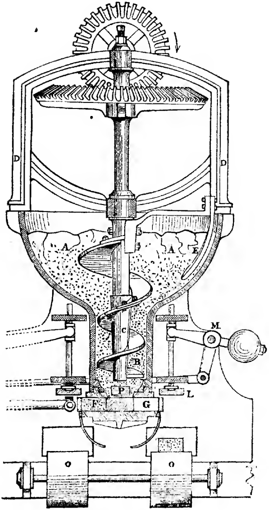


Fig. 2.



The cast-iron clay cylinder A is expanded at the upper part to form a hopper, into which the clay is supplied,. and the lower cylindrical portion is about the same in

Fig. 3.



diameter as the length of the brick mould F, at the bottom of the pressing chamber B. The vertical screw C is placed in the axis of the cylinder, and carried by

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two bearings in the upper frame D; this screw is parallel at the lower part, the blade nearly filling the parallel portion of the clay cylinder, and is tapered conically at the upper part to nearly double the diameter. When the clay is thrown loosely into the hopper it is divided and directed towards the centre by the curved arm E revolving with the screw shaft, and drawn down by the tapered portion of the screw into the parallel part of the clay cylinder in sufficient quantity to keep this part of the cylinder constantly charged. The clay is then forced downwards by the parallel portion of the screw into the pressing chamber B, and into the brick mould F, which consists of a parallel block equal in thickness to a brick, and sliding between fixed plates above and below, and containing two moulds, F and G, corresponding in length and breadth to the bricks to be made. The mould-block F is made to slide with a reciprocating motion by means of the revolving cam H, which acts upon two rollers in the frame I, connected to the mould-block by a rod sliding through fixed eyes; and the two brick moulds are thus placed alternately under the opening of the pressing chamber B to receive a charge of clay, the mould-block remaining stationary in each position during one quarter of the revolution of the cam H. When the brick mould F is withdrawn from under the pressing chamber, the brick is discharged from the mould by the descent of the piston K, which is of the same dimensions as the brick mould; the piston is pressed down by the lever M, worked by the cam N, when the brick mould stops at the end of its stroke, and is drawn up again before the return motion of the mould begins. A second piston L acts in the same manner upon the second brick mould G, and the discharged bricks are received upon endless bands

O, by which they are brought successively to the front of the machine, when they are removed by boys to the barrows used for conveying them to the kilns to be burnt.

The solid block that divides the two brick moulds F and G is slightly wider than the discharge opening at the bottom of the pressing chamber B, having an over-lap, so that the making of one brick is terminated before that of the next begins, in order to ensure completeness in the moulding. During the instant when this plank is passing the opening at the bottom of the pressing chamber, the discharge of the clay is stopped, and it becomes necessary to provide some means either of relieving the pressure during that period, or of stopping the motion of the pressing screw. Accordingly the pressure is relieved by an ingenious contrivance, forming in effect a safety-valve, which prevents the pressure in the chamber from increasing when the brick mould is shut off, and also serves to maintain a uniform pressure during the formation of the brick, so as to ensure each mould being thoroughly and equally filled with clay; this is effected by an escape-pipe P, similar in form to the brick mould, but extending horizontally from the side of the pressing chamber, and is open at the outer extremity. The regular action of the screw forces the clay into the escape-pipe, as far as its outer extremity, forming a parallel bar of clay in the pipe. The resistance caused by the friction of this bar in sliding through the pipe is then the measure of the amount of pressure in the machine; and this pressure cannot be exceeded in the machine, for the instant that the brick mould is full, the further supply of clay, fed into the pressing chamber by the continuous motion of the screw, escapes laterally, by pushing outwards the column of clay in the escape-pipe. The uniform pressure of every brick in the mould up to this fixed limit is ensured by the escape-pipe not beginning to act until that limit of pressure is reached. Its action is similar to that of a safety-valve, and the amount of pressure under which the bricks are made is directly regulated by adjusting the length of the escape-pipe. The latter discharges a continuous bar of solid clay, advancing by intermittent steps of ¼ to ½ in. in length, each time that the brick mould is shut off and changed. The projecting piece of clay from the end of the escape-pipe is broken off from time to time, and thrown back into the hopper of the machine.

The upper side of the solid block separating the two moulds F and G is faced with steel: and the upper face of the brick is smoothed by being sheared off by the edge of the opening in the pressing chamber; the under face of the brick is smoothed by being planed by a steel bar R, fixed along the edge of the under plate, and having a groove in it for discharging the shaving of clay taken off the brick.

The screw shaft is driven by bevil gear from the shaft S, which is driven by a strap from the engine, the speed being adjusted according to the quality of the clay or the wear of the screw. The screw is driven at about thirty revolutions per minute, when at full speed, or one brick for each revolution of the screw. The machine completes 12,000 bricks per day, or an average of twenty per minute. The clay, as already stated, can be taken direct from the pit, passed through crushing rollers, and then fed straight into the moulding machine. Indeed, the clay within a quarter of an hour after being brought from the pit may be seen stacked in kilns, and in a few days burnt ready for use. The amount of power required for driving the machine, and the wear of the screw, vary according to the material worked. With a calcareous marl about twelve horse-power was found sufficient. When the material is very siliceous the cast-iron screws wear out quickly. Gun-metal has been found much more durable than iron for the screw and mould-block.

In burning bricks that contain much alumina, and consequently retain a good deal of moisture, it is found advisable to stack the bricks in the kiln in *lifts* of from fifteen to twenty courses each. As soon as the bottom lift has been stacked, small fires are lighted to drive off the steam from the bricks, which might otherwise soften those stacked above; the middle lift is then stacked and similarly dried, and then the top lift; after which the full fires are lighted.

The crushing strength of these bricks made in the machines at Oldbury is said to be double that of the hand-made blue bricks of the neighbourhood, being an average of 150 tons compared with 76 tons, or 8,024 lbs. per square inch compared with 4,203 lbs. The transverse strength, with 7 in. length between the bearings, was found to be, for hand-made bricks, 2,350 lbs., for machine-made bricks, 3,085 lbs., and for the same, hard burnt, 4,320 lbs.

One of the advantages of this machine is, that clay containing a good deal of stone, which could scarcely be worked for hand-made bricks, can be used. The brick-earth at Cobham is very unfavourable for brick-making, it being so weak and friable that hand-made bricks made from it were crushed by a moderate pressure; when made by the machine, however, serviceable bricks were turned out. A material containing 84 per cent. of silica has been made by this machine into bricks. The bricks had not any hollow or *frog* in the upper space for holding the mortar, but arrangements were being made for producing it.

The extent to which bricks absorb water is important, since dry houses cannot be built with bricks that are very absorbent. A brick of 9 lbs. weight will absorb about 1 lb. of water, and it is stated that the bricks made by this machine absorb less.

The cost of Oates's machine is from £150 to £200, exclusive of the engine for driving it. The cost of brick-making varies according to the price of coal in different localities; but there is very little variation in the price of the unburnt bricks made by the machine, the difference arising chiefly from the varying amount of royalty charged on the clay in the pit, which varies from 1*s.* to 2*s.* 6*d.* per 1,000. A machine at Cobham, employed by Messrs. Peto and Betts, produced 200,000 bricks in a fortnight of eleven days, but the average number per week, of five and a half days, was considered to be 80,000, or at the rate of twenty-four bricks per minute. The contract for the bricks in and out of the kilns, exclusive of the cost of the coals, was first taken at 5*s.* 9*d.* per 1,000 bricks; which was afterwards raised to 6*s.* 9*d.*, owing to the distance of the clay from the machine. To this had to be added 6*d.* per 1,000 royalty, and the wages of the engine-driver at 6*d.* per 1,000, raising the expenses to 7*s.* 9*d.* per 1,000 bricks. The quantity of coals required for burning the bricks, and for the engine driving, might safely be taken at ½ ton per 1,000; and the price of coal at that place being 25*s.* per ton, the total cost of making the bricks by the machine amounted to 20*s.* per 1,000, including the burning.

The following particulars respecting drain-pipe making machines, and hollow bricks, are also from Mr. Tomlinson's "Cyclopædia."

The large and increasing demand for draining tiles and pipes has led to great economy in their manufacture. Some are moulded flat, and afterwards bent round a wooden core to the proper shape: others are made at once of a curved form by forcing the clay through a *dod* or mould, fig. 4, by mechanical pressure. The action will be readily understood from fig. 5, which represents a section of a strong iron cylinder, containing a quantity of clay in the act of being pressed down with enormous force by a solid piston or plunger. The clay, as it escapes through the dod, is evidently moulded into the form of the pipe (also shown in section), which is cut off in lengths, by means of a wire, and these, after a preliminary drying, are ready for firing. By using dods of different sizes, pipes of various magnitudes are formed.

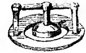


Fig. 4.

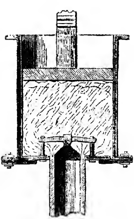
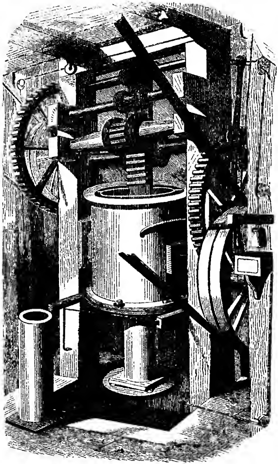


Fig. 5.

Fig. 6 is an elevation of a drain-pipe making machine, which we have copied from Mr. Green's works at Lambeth. The cylinder contains a second cylinder, capable of holding a given weight of clay, adapted to the moulding of a certain number of pipes at one charge. Thus, one *box-full* will furnish five 9-in. pipes, six 6-in. pipes, seven 4-in. pipes, and so on. By the action of the rack the piston forces the clay through the dod or die upon a table, so balanced by weights that the lengthening pipe is sufficient by its weight to force down the table, and when a certain length of pipe is formed, the boy stops the machine by shifting the strap which drives the rack-screw from the fast to the loose pulley, and then cuts off the length of pipe with

Fig. 6.

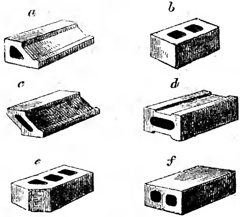


a wire, removes the pipe so formed, raises up the table, sets the machine in action, and receives a pipe upon the table as before. When all the clay is thus forced out of the cylinder, the action of the rack is reversed, whereby the plunger is drawn up out of the cylinder. The cylinder, which moves on a kind of hinge, is then tilted on one side to receive its charge of clay, and being restored to its vertical position, the action proceeds as before. By an ingenious contrivance, the fork which shifts the strap from the fast to the loose pulley, is weighted in such a manner that, when the boy raises his foot from a treadle, the strap is at once moved on to the loose pulley, and *vice versâ*, thus giving the attendant a third hand, and diminishing the chances of danger from the strap. Mr. Green has a machine worked by a screw, in which the process is continuous. These pipes are washed with glaze before the firing, as will be explained hereafter.

By means of a tile machine, the *hollow bricks* are formed, which are so much recommended by the "Society for Improving the Condition of the Labouring Classes," and introduced by them in the construction of dwelling-houses for the poor. The idea of tubular bricks is not new, for such articles were used by the Romans in large vaultings, where lightness of construction was required, and they are said to be in common use in Tunis at the present time. The size of the bricks is 12 in. long, and three courses rise 1 ft. in height. Nine hollow bricks will do as much walling as sixteen of the common sort, with only a slight increase in weight. In passing through the tile machine, or in the process of drying, the bricks can be splayed at the ends for gables, or marked for closures, and broken off as required in use, or they may be perforated for the purpose of ventilation. If nicked with a sharp-pointed hammer, they will break off at any desired line; and the angles may be taken off with a trowel as in the common brick. The bricks for the quoins and jambs may be made solid or perforated, and with perpendicular holes, either circular, square, or octagonal: those in the quoins may be so arranged as to serve for ventilating shafts. The hollow bricks, from their mode of manufacture, are more compressed than common bricks, require less drying, and are better burned with less fuel.

The following figures represent some of the forms of hollow bricks in common use. *a*, fig. 7, is an *external* brick, $11\frac{3}{4}$ in. long, which with the *quoin* brick *e*, and the *jamb* brick *b*, are sufficient for building 9-in. walls. *e* is $10\frac{1}{4}$ in. long, with one splayed corner for forming external angles, reveals, and jambs of doors and windows, either square or splayed. The *internal jamb* and *chimney* brick, *b*, is $8\frac{3}{4}$ in. long; *c* is an internal brick, adapted to any thickness of wall beyond 9 in.: *d* is for $5\frac{3}{4}$-in. partitions, or internal walls, and arch bricks, and is used for floor and roof arches of 7 to 10 ft. span. *f* is used for the same purpose, with

Fig. 7.



a webb to give extra strength, and to adapt them for using on edges in. partitions, 3¾ in. thick to rise in 6-in. courses.

Fig. 8 represents a specimen of hollow brick work in 6-in. courses, with square rebated joints for extra strength. These bricks are adapted to the lining of flint or concrete walls. Fig. 9 is a section illustrative of the construction adopted in H. R. H. Prince Albert's model houses. The span of the arches is increased over the living rooms to 10 ft. 4 in., with a proportionate addition to their rise. The external springers are of cast-iron, connected by wrought-iron tie rods.

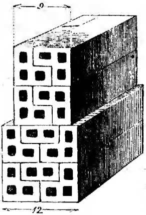
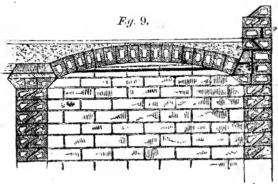


Fig. 8.

It is stated that there is an advantage of 29 per cent. in favour of the patent bonded hollow bricks over ordinary bricks, in addition to a considerable diminution in the cost of carriage or transport, and of 25 per cent. on the mortar and the labour.

Fig. 9.



CHAPTER IX.

ADDITIONAL REMARKS ON THE MANUFACTURE OF BRICKS BY MACHINERY.

It is proposed here to supplement the previous chapter, written by Professor Tomlinson in 1863, by giving full descriptions of some of the most remarkable, or most used, of the very many brickmaking machines now before the public. The trade in producing brick machinery itself has come to be a very large one, in which great intelligence, energy, and capital have been invested, and from which have emanated an immense number of inventions, chiefly the subjects of patents. The results have naturally been much rivalry and competition, so that, perhaps, there is no one of the trains of machinery for making brick, which has had a success enough to make it worth notice, which has not been exposed to partial advocacy, and to equally interested and frequently more unjust depreciation.

It would be highly out of place that "an outline" such as this volume can alone pretend to, within its limits, should undertake to appraise the relative merits or demerits of the various machines we are about to notice —the rather, as we are unable to treat the whole subject in the exhaustive manner that alone would justify such criticism. The following notices, therefore, must be viewed as merely collecting before the reader, with sufficient illustrations, a few of the more prominent brick and tile machines, or those most in use in Great

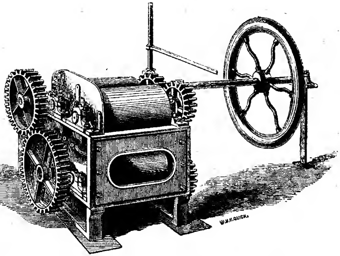
Britain, sufficient to serve as an index to those specially interested, whereby more complete information may be obtained through the respective makers or otherwise.

As has been sufficiently shown in the preceding parts of this volume, the natural clays from which bricks are to be made, though they *may* occasionally be found in a state capable of being at once made into brick, must most usually be subjected, after having been dug out, to more or less disintegration, grinding, and mixing into perfect plasticity, before being employed. For these purposes, the screen sometimes being used beforehand, the crushing rollers and the pug-mill are employed. Other methods of producing perfect freedom from adventitious matter and perfect plasticity are occasionally employed, when special qualities of extra fine bricks are sought for, but with those we need not trouble the reader here.

The above machines are employed in combination, *i.e.*, as parts of one compound machine, as produced by some makers, separately as turned out by others. The clay-mill, with crushing rollers working on edge in a circular pan, is also in use. Brick machinery itself, since the invention of Prosser, many years since, is divisible into two great classes, wet and dry clay machines, *i.e.*, machines which form the brick, by moderate pressure in moulds, from already tempered and plastic clay, and those which, under a far more severe compression, mould the bricks from clay perfectly comminuted, but either dry, or at most only very slightly moistened. One of the most salient advantages of the dry method is, that it produces a denser brick, and one that shrinks less both in drying and in baking than do those made wet; and that a certain amount, though not a very great one, of the labour and cost of the preliminary preparation of the clay is saved. The disadvantages, or some of them, are, that unless the clay in the dry or merely damp state be scrupulously well prepared, and unless a degree of pressure be employed which demands a good deal of power, the brick may be deficient in tenacity and in uniform solidity, or even in perfect fairness of face. On the other hand, with certain clays, and pressures beyond a given point, bricks are thus produced, which, though dense and resistant, have so *un*porous a surface as hardly to take bond with either cement or mortar.

Fig. 1 represents Whitehead's Improved Clay Crushing and Grinding Roller Mill, consisting of two pairs of large iron rollers, fitted in a massive cast-iron frame. The dimensions of the top rollers (which revolve at equal speed) are 2 ft. 6 in. long by 1 ft. 8 in. diameter. The lower pair (running as two to one, for more thoroughly incorporating the clay) are 2 ft. 6 in. long by 1 ft. 6 in.

Fig. 1.



diameter. The above mill is constructed for the purpose of reducing rough strong clays or hard marls not disintegrable by water, into a state to be rendered plastic by future operations in the pug-mill, of which two different examples are given in figs. 2 and 3 by the same maker.

Fig. 2.

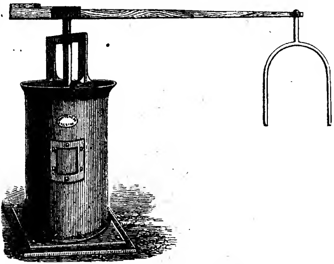


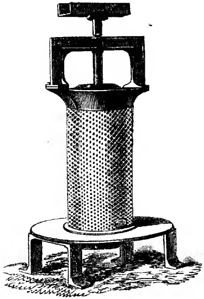
Fig. 2 is a large and powerful pug-mill. The cylinder is one strong loam casting made perfectly true; it is erected upon a massive iron basement, and provided with two cast mouth-pieces for the discharge of the pugged clay, one situate on each side at bottom. These mouth-pieces may have sliding doors fitted, to increase or diminish the area of the orifice, so as to cause the clay to be more or less finely ground. This is valuable in admitting the adaptation of the mill to the pressing out of large and small pipes, &c.

This mill makes about three revolutions per minute, worked by the power of one horse. The cylinder is 24 in.

diameter inside, and 54 in. high; the total height to top of vertical shaft is 87 in.

Fig. 3 represents Whitehead's Perforated Pug-mill. The advantage of this mill is, that during the operation of pugging the clay is forced out through the perforations at the sides in the plastic state, leaving behind the stones, which are carried, by means of the internal arrangement of the knives on the vertical shaft, through an aperture at the bottom; thus combining the process of pugging and screening in one operation.

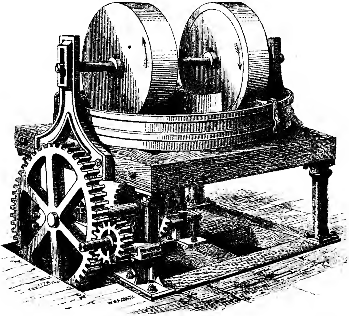
Fig. 3.



We entertain some doubts of the advantages of this machine, however ingenious; for screening as a preliminary operation should, whenever practicable, never be omitted.

Fig. 4 shows a very good form of nearly portable clay-mill. Mills in this form *may* be used for grinding wet or plastic clay, but are more suitable for indurated **dry** clays, which are to be used with one or other of the **dry-clay** brick machines. The pan, as is evident from the figure, revolves, and the runners are carried round by it, being free to move within a certain range vertically. The pan is provided with curved blades, so fixed as to keep the stuff constantly beneath the runners.

Fig. 4.

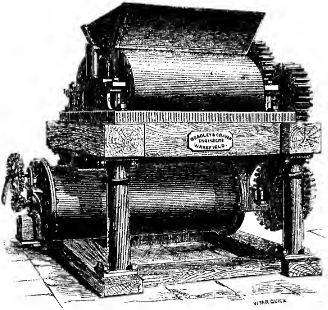


We now come to the composite machines, in which crushing rollers and horizontal pug-mill are combined, as in fig. 5.

For very hard clays, such as fire-clays for fire-brick, two or even more pairs of crushing rollers may be needed above each other, those closest set being at bottom.

The rollers are driven at different speeds, so as to produce a *rub* as well as a mere squeeze between the surfaces, and so better disintegrate the clay. The rollers are usually made about 20 in. diameter, and about 3 ft. long. They are fed by hand, through a hopper at top.

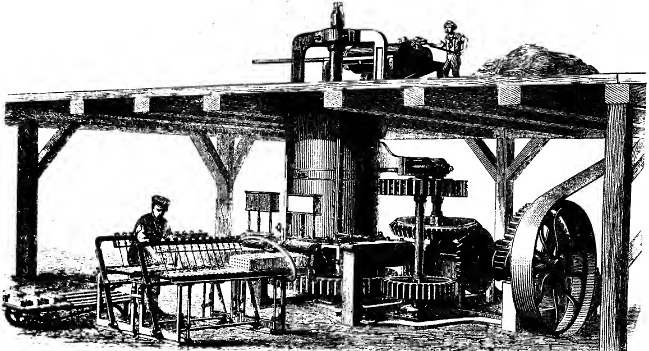
Fig. 5.



Having thus described the machinery generally in use for the *preparation* of the clay, whether plastic or dry, we proceed to illustrate a few of the brickmaking machines themselves, commencing with those for operating on moist or plastic clays.

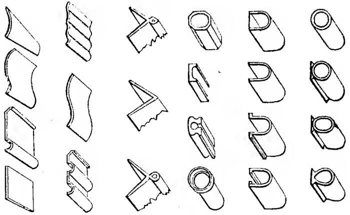
Fig. 6 represents a large machine as constructed by Whitehead, of Preston, in which the rough clay thrown in between the rollers at top is ground, and then passes

Fig. 6.



at once into the vertical pug-mill, and is thence expressed in two continuous prisms of the size in section of a brick

Fig. 7.

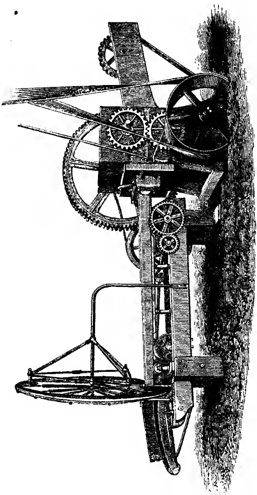


on flat, and which are at intervals cut transversely into bricks by the wires of the frames, seen in the front of the drawing. These are moved by hand.

Fig. 8 represents another form of machine, in which the clay, already tempered, is drawn in and continuously expressed by a pair of rollers, the prism being cut asunder into bricks by the radial wires forming the arms of the wheel C, which is moved automatically.

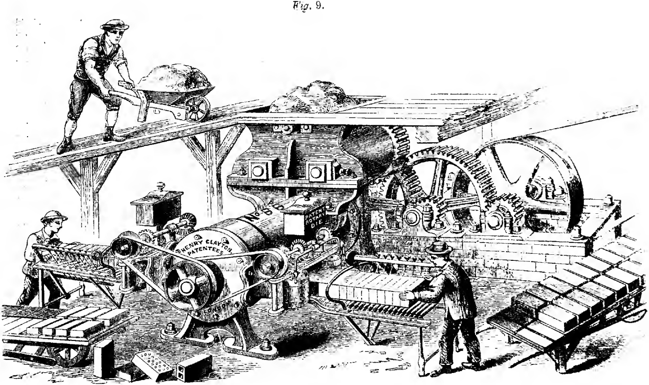
An extremely simply-contrived and most efficient French machine of this class was exhibited in 1862 in the French department. It was an invention of M. Jardin, and manufactured by Cazenave & Co., Paris. At work in the Exhibition, it made at the rate of twelve thousand per day of ten hours, with only the attendance of two men. The division of the prism of clay was effected by wires attached to a wheel moved by the machine, but differently arranged from that of fig. 8.

Fig. 8.



The following machine belongs to this same class. It is Clayton and Co.'s second-sized horizontal brick

Fig. 9.



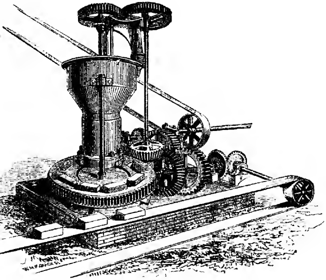
machine, which combines the crushing rollers, pugmill, and brick-forming in one machine.

These machines are largely run upon, and have been employed extensively by our great contractors, and upon many public works—facts which give the best assurance that they answer well.

One of these machines weighs about 3½ tons, and of this second size, with about 8 or 10 horse power, will turn out from 75,000 to 90,000 bricks per week.

We now come to another class of machines working

Fig. 10.



with plastic clay, though capable of employing clay nearly dry, or at least very stiffly tempered. The machine shown in fig. 10 consists of a vertical pug-mill, into the upper part of which the clay is fed, and in which it undergoes tempering and mixing, and, on reaching the bottom of the mill, is pressed into the moulds, of the form and size of brick required, which are arranged in the form of a circular revolving table. As this table revolves, the piston-rods of the moulds ascend an inclined spiral plane, and so gradually lift the bricks out of the moulds, whence they are taken from the machine by a boy, and placed on an endless band which carries the bricks direct to the "waller." The speed of the several parts is so arranged, that the operations of pugging, moulding, and delivery proceed simultaneously in due order, the whole being easily driven by a steam engine of about 6-horse power, which, at the ordinary rate of working, will make 12,000 bricks per day; or with 8-horse power from 15,000 to 18,000. In consequence of the great pressure to which the clay is subjected in the moulds, the bricks produced by this machine may be made from stiffer clay, so that less water has to be evaporated in the drying, thus saving much of the time required for hand-made bricks, and avoiding the risk of loss from bad weather.

One point of importance to remark as respects this last class of machines, compared with the previous one, is this—wire-cut bricks are smooth and perfect in form, provided the clay be not only perfectly plastic, but *perfectly uniform* and free from adventitious particles. If, however, the plastic clay contains gravelly particles, or be of such a quality that it is necessary to mix it with ashes or "breeze," then the section made by the passage of the wire drags out and after it more or less of these solid particles, and the faces of section are rough and uneven; in such cases resort is best had to those machines of pressure only.

In the following brick-pressing machine also, for plastic clay, the moulded bricks are delivered by the machine directly on to the horizontal belt that carries them away; so that the labour of attendance is nearly limited to feeding the tempered clay into the top hopper. We are not aware to what extent as yet this ingenious machine has been employed.

Figs. 11, 12, 13, and 14 illustrate a brick-pressing machine recently patented by Mr. W. Longley, of Leeds. The invention relates to an arrangement of brick-moulding machinery, whereby bricks are produced from "wet" clay, having great solidity, with a smooth exterior, and containing a less amount of moisture than those produced by hand, or by machinery at present in use.

Fig 11 is a side elevation of the machine; fig. 12 is a partial end elevation, showing in longitudinal section the cylinder which carries the moulds, and presents them successively to a conical hopper to be fed with clay; fig. 13 is a cross section of the mould-cylinder, showing its connection with the hopper; and fig. 14 shows the means used for locking the cylinder, so as to keep the moulds stationary while being filled and discharged.

A A is the main framing of the machine, upon which is mounted in suitable bearings a horizontal cylinder B. This cylinder is cast with open ends, and it is fitted near the middle of its length with a series of four moulds, C C, arranged radially around it. These moulds are formed by recesses cut through the periphery of a projecting band *a a*, that surrounds the cylinder, having their ends closed by the rings *b b* (bolted to the cylinder): a series of close chambers, D D, are formed in a similar manner between the moulds for receiving steam for heating the latter. Immediately above this concentric projection of the cylinder B, and in close proximity thereto, is situate the hopper E, in which a screw

Fig. 11.

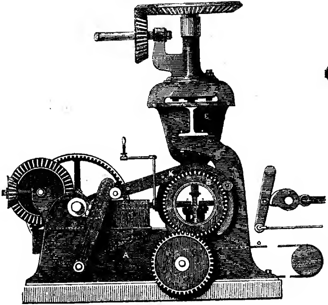
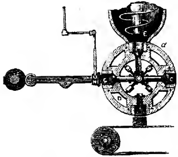


Fig. 13.



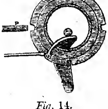
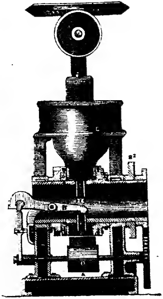


Fig. 14.

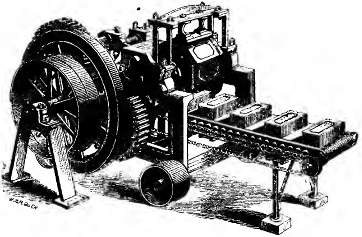
Fig. 12.



is mounted for forcing down the clay into the moulds as they are presented to the former. Fitted into the moulds are plungers, F, the stems of which project through the inner periphery of the cylinder B, and are intended for discharging the bricks from the moulds; the inner periphery of the cylinder B is also pierced to receive the ends of a cruciform arrangement of steam pipes, G (fig. 13), for supplying steam from a central pipe running in the direction of the axis of the cylinder to the chambers D; an intermittent axial motion is given to the cylinder, for the purpose of bringing the moulds severally under the hopper to be filled, and subsequently under the action of a plunger the clay thus filled into the mould presented to it is compressed therein. When this is effected, and the cam in its revolution has passed out of action, the weighted crank lever draws back the plunger N out of the mould. Another movement of the cylinder B now takes place, and the compressed brick is brought down to the position for being discharged on to an endless apron O. This is effected by the stem of the plunger, F, of the mould, being pressed upon at its rear end by the rocking lever H. This rocking lever is mounted on a bent bracket arm attached to the main framing, and it is provided with a roller, which bears upon a rocking cam having a stud pin on the framing for its fulcrum. This rocking cam is jointed to a rod, which connects it with a rocking arm, pendent from a bracket on the framing. The arm carries a roller which bears against a cam on the cam shaft; the revolution therefore of the cam shaft gives a reciprocating motion to the cam H, thus causing it to rock the lever H, and depress the plunger that has been brought beneath its inner end. This depression of the plunger effects the discharge of the brick, which is facilitated by the heating of the moulds through the admission of steam as before explained. To prevent the adherence of the clay to the compressing plunger, that is made hollow, and steam is conveyed into it by an arrangement of jointed steam pipes, as shown at fig. 11. The discharged brick is received on to an endless apron, O, which receives motion from the spur wheel on the cylinder B, gearing into a spur wheel on the axle of one of the carrying rollers of the apron. The cylinder B is also furnished with a ring, in the periphery of which are four notches, corresponding with the moulds. These notches (see fig. 14) are for the purpose of receiving the taper end of a locking bar P, which, when it is desired temporarily to lock the cylinder (as at the moment of filling, pressing, and discharging the moulds), is thrust forward by a cam on the cam shaft pressing upon a roller, mounted on the end of the locking bar, which slides in guides provided to receive it. The release of the cylinder is effected by throwing back the locking bar by means of a weighted crank arm, as in the case of the compressing plunger.

This machine (fig. 15), the subject of a patent, is made by Whitehead, of Preston; it works upon tempered clay also. The merits claimed for it consist in simplicity of construction and efficient performance. The junk of clay or brick may be previously moulded as for other pressing machines, but with this machine it is not absolutely necessary to previously mould the lump, if only sufficient clay be supplied to make a brick, and be simply placed in front of the piston; it then is forced into the mould or die (of which there are four on a revolving shaft) of the desired size, and any superfluous bulk of the clay is cut off, thus making all the bricks perfectly true and of uniform dimensions. During the return of the piston the box of dies or moulds revolves one-fourth of the way round, thus bringing another empty mould, which has already been oiled and cleaned by a self-acting lubricator, directly opposite the piston, to receive the next brick. In the meantime, a self-acting push-plate forces the brick, already pressed, out of the die upon a self-acting table prepared for carrying it away.

Fig. 15.



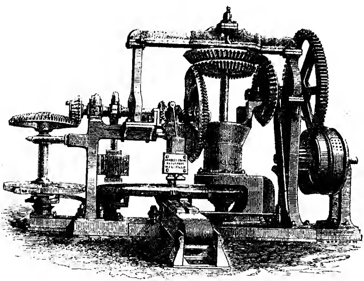
The following well-arranged machine belongs to the class which can operate upon either plastic or dry clay, but which is, in our opinion, best adapted to the former. The makers and patentees, Messrs. Bradley and Craven, of Wakefield, have had a large experience in machinery of this sort.

Simplicity of parts and strength are the main characteristics of this machine.

If the material be coarse or strong, it must be crushed before being passed into the hopper, into which it may be delivered either with or without water.

Two moulds receive the charge of clay at once. While these are being filled, the two that had been

Fig. 16.



just before filled are being subjected to a considerable pressure, and the two bricks that had just previously to that been so pressed are in process of delivery, out of the moulds and on to a flat belt which takes them away.

For the production of smooth, well-squared facing bricks this machine works extremely well.

We now arrive at the last class, namely, of machines intended specially to operate upon dry clay, or nearly dry clay.

Amongst these we may notice the patent machine of Hersey and Walsh, which has been recommended by a competent authority—Mr. Humphrey Chamberlain, Consulting Pottery Engineer, formerly of Kempsey, near Worcester.

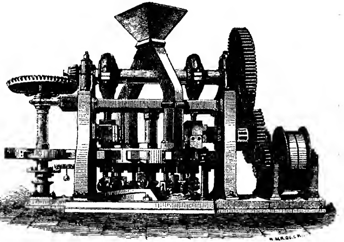
This machine is stated to have been an American invention, which attracted attention from the simplicity of its movements and the enormous power it was capable of exerting with a small amount of friction. It was found working successfully in the United States, and arrangements made for its introduction in this country. It produces an excellent article, and works satisfactorily here also.

Some few alterations had to be made to adapt it to English-sized bricks, as American bricks are little more than one-third the cubical contents of the English. The weight of these machines is about 25 tons, which is necessary to withstand the enormous pressure they are capable of exerting. They are made with any number of moulds from 2 to 8. With 6 moulds, and driven by a 6-horse engine, to deliver 24 bricks per minute, one machine is capable of giving 330 tons pressure on the 6 bricks; and if worked by a more powerful engine, the pressure can be increased, only limited by the strength of the machine. As few clays require more than 20 or 30 tons on a brick, from 4 to 5 horse power is ample. The motions of this machine are performed by a pair of cam wheels, the pressure being communicated by a pair of rollers running on the cams, with the mould pistons fixed on the shaft between them. The moulds are raised and lowered by the same cams. The bricks are delivered and the moulds re-fed with dry clay from the hopper by a feeder worked by friction. The machine, after pressing 6 bricks, delivers them on a board ready for removal, so that they go direct to the kilns without being handled or injured. The whole machine is fixed on one bed-plate, and is made of such strength as not to be likely to get out of order.

The following machine will afford a sufficiently clear notion of the construction, or at least the general principles of construction, of the great majority of dry-clay brick-machines which have been brought into successful action.

Fig. 17 represents the dry-clay brickmaking machine, of which Messrs. Bradley and Craven, of Wakefield, are the inventors and patentees.

Fig. 17.



One of the disadvantages or difficulties of making perfectly sound and solid bricks from completely dry clay, however finely pulverised, is that the air lodged in the interstices of the clay dust is sometimes not easily and completely expelled by a single compression, but lodges in one or more irregular cavities into which it has collected, and so leaves the brick hollow. One of the main objects of this machine is to obviate that evil, which is proposed being accomplished by its possessing the power of relieving each brick from pressure, and again applying it, so as gradually to force out the air, and finally consolidate the brick, and that to an extent that a single pressure, though greater, and hence exerting a greater strain on the machine, might not accomplish.

The patentees state: "By this machine two or three distinct pressures can be given to each brick. If two pressures (that is, upward and downward) are sufficient to produce a good article from the clay, then the machine makes two bricks at a stroke, or for every revolution one brick by each eccentric. If the clay is of such a character that the whole of the air cannot be expelled, or the dust sufficiently condensed to make a perfect brick by two pressures, then a third is given by carrying the brick round under the second eccentric. With most clays two pressures will be found sufficient. It is only necessary to test a little of the clay to be worked so that the machine may be adjusted to mould and press from *any kind of earth* equally good bricks. The only change for giving three pressures is, to adjust the machine to run faster, and change the inclined plane for giving the upward or first pressure, and delivering the bricks. The action of the machine is easily understood. The clay being delivered by an elevator from the crushing rollers into the hopper of the machine in motion, the tappet wheel turns the mould table the length of one mould. This action delivers two empty moulds under the hoppers to receive clay, delivers two bricks to the attendant, and gives a powerful upward pressure to the clay received in the moulds that have just left the hoppers. The table is then for a moment stationary, while the two eccentrics give the final strain on two bricks. When the eccentric pistons are clear of the moulds the tappet again turns the table one brick's length, and the same action is renewed. During the time the eccentrics are giving pressure, the table is held firmly by a stop, which is then released."

The last of this class which we shall notice is the dry-clay machine of Wilson, of Campbellfield Brickworks, Glasgow, which was exhibited in action at the Exhibition of 1862.

The peculiarity of working of this machine is, that the dry and pulverised clay prepared for being made into brick is carried along automatically to the hopper, and, just before being delivered into it, is subjected to being blown upon by the waste steam discharged from the non-condensing engine which drives the machine. The result is a slight *condensation of steam on and in the pores* of the clay, and a slight *warming of the clay* itself. From this arises a much-increased tendency to rapid and perfect agglutination in the clay when submitted to pressure in this state, between wet and dry, and a much readier expulsion of the air involved in the mass. There is not the slightest doubt of the great advantage derived from this very simple mode of treating the dry clay prior to compression.

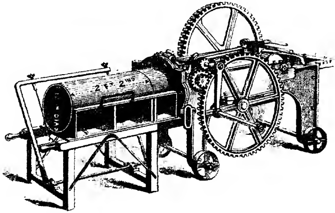
There are several contrivances in Mr. Wilson's machine, as to details, also of value, especially one by which the maximum pressure possible is so regulated that the destruction of the machine is guarded against.

One great improvement yet remains to be made to render perfect dry-clay brickmaking machines, namely, to adapt to them the same method that was employed by Mr. Brockedon, in his patent for compressing dry powder of plumbago into a dense and solid block to be sawed into pencils, namely, the *operating the compression in a vacuum*, so that the air involved between the particles of dry clay (or dust, if quite dry) being thus extracted, the mechanical pressure is free to act fully and solely in producing condensation and agglutination of the clay particles.

Any one of the brick machines of the first class, down to fig. 8, inclusive, may, by a suitable alteration of the discharging dies and receiving tables, be made to express and form perforated bricks, moulded bricks, drain or other pipes, or tiles of any sort, as in Fig. 7.

We shall therefore confine our illustrations of tile-making machinery, specially so designed, to two examples, viz., to fig. 18, the large drain-pipe machine of

Fig. 18.



Page and Co., of Bedford, which forces out a continuous hollow cylinder from the plastic clay (as at A fig. 19), and fig. 19.

The machine by Whitehead, of Preston, for pressing one end of the cylinder so cut off to a given length, as

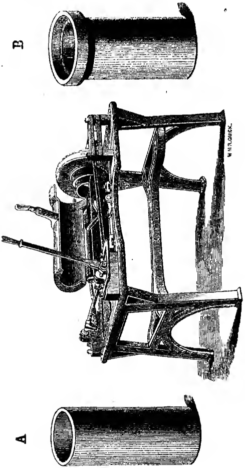


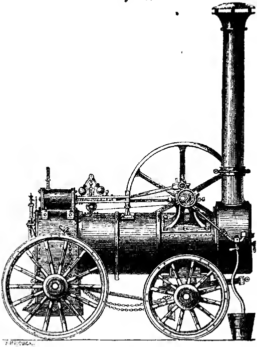
Fig. 19.

at A, into the socket form, as at B, fig. 19, so that the lengths shall go together with spigot and faucet joints.

Dies of various forms, prepared to adapt to any of the brick or tile machinery, are supplied by the makers, by which almost any form (solid or hollow, tubular or multitubular, *i.e.*, perforated like "perforated brick"), that can be produced by the advance of a given section parallel to itself, may be formed. The figures in Fig 7 show a few of the more usually employed sections—those at the right being drain-pipes, those in the middle for building purposes, and the left-hand ones for roofing use.

In addition to the machines for brick and tile making, which we have thus pretty copiously illustrated, there are other machines almost innumerable for making special forms in plastic or in dry clay, referable to the great family of bricks and tiles. A great tribe of these machines, to which our space forbids our making any allusion, is employed in Great Britain and abroad in the manufacture of encaustic, or inlaid, or intaglio tiles for flooring and other architectural purposes. Those who desire still more complete or enlarged information on the subject of this class of machinery should consult the *Practical Mechanic's Journal Record of the Exhibition of* 1862, Mr. D. K. Clarke's "Exhibited Machinery of 1862," the Reports of the Juries of Exhibition, 1862, and the volume of Abridgments of Patents, relating to drain tiles and pipes, bricks, tiles, and pottery, issued by the Patent Office, extending from 1619 to 1861. There have been many patents since that date, and many descriptions of machines of more or less value are also to be found scattered through the British and foreign mechanical journals, in encyclopædia articles, &c. Though not important for those employing brick machinery at home, it may be desirable, for the information of British colonists, that we should indicate the form of portable high-pressure steam engine most usually employed for actuating such. It is that shown in fig. 20, being one of this class of engines manufactured by Clayton and Shuttleworth. When bricks, &c., are required for a special contract or some private work presenting but a terminable demand, such

Fig. 20.



portable engines are the best and cheapest in every way; but, for a great and permanent brickmaking establishment, engines upon fixed bed-plates or foundations are to be preferred.

In concluding these notices of the apparatus of the mechanical brick and tile maker, we must not omit to call the reader's attention to probably the greatest improvement that has ever been made in the construction of kilns, for at once drying and burning brick, viz., the patent brick-kiln of Hoffmann.

This kiln is, in fact, an admirable adaptation to brick drying and burning of Siemens's regenerative principle of furnace, as will be apparent from the following account, abridged chiefly from a paper by Professor James Thomson, of Belfast. Fig. 21 is a half-plan on top of the kiln, the other being a horizontal section at

Fig. 21.

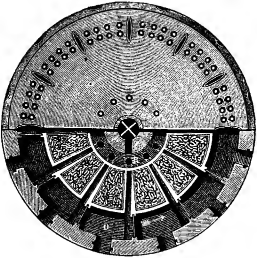
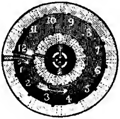
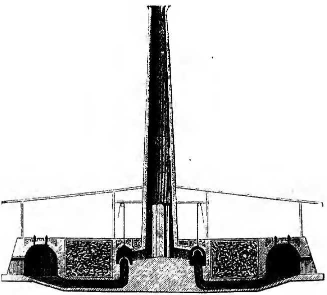


Fig. 22.



the level of the flues, leading into the central chimney-stalk, as seen in the vertical section, fig. 23. Fig. 22 is a diagram of the whole to a reduced scale, which is referred to in illustrating the description of the mode of working of the kiln.

Fig. 23.



The accompanying engravings illustrate this remarkable form of kiln, invented by M. Hoffmann, of Berlin, but patented in England by Mr. H. Chamberlain, who supplies designs for their construction, &c. Some sixty of these kilns are already at work on the Continent and in Great Britain. The furnace or oven consists of a circular channel, O, of any section, which receives the objects to be fired, introduced through doors in the outside wall; the fuel is fed in by apertures formed in the top of the arch. Flues lead from the bed of the furnace to the smoke-chamber R, which surrounds the base of the central chimney, the communication with which can be cut off when required by means of cast-iron bell-shaped covers. An intercepting damper can be lowered or placed in grooves built into the walls of the furnace immediately behind each flue, so as to separate it at any distinct or equidistant compartment. The fuel passes through apertures which are constructed in the arch, and falls through channels formed by the objects to be burnt to a chamber in the bed of the furnace, from which a certain number of small flues radiate to produce a free current from fire to fire. In practice it is found better to divide the kiln into twelve chambers, to which there are twelve entries or doorways, and the same number of flues communicating with the smoke-chamber, and just as many openings in the arch for the reception of the large intercepting dampers—thus the furnace can be divided at any one of the twelve parts. For clearer distinction, these compartments may be numbered, as in fig. 22, from 1 to 12, of which two, Nos. 12 and 1, we will suppose are separated by the intercepting damper. The objects to be burned may be bricks or tiles, &c. Suppose the fire in full operation—the doors leading to the compartments 1 and 2 being open, No. 1 for filling it with fresh goods, and No. 2 for taking out those already burnt. The chambers Nos. 3, 4, 5, and 6, which are all filled with burned goods, are gradually cooling by the air entering through the doors of Nos. 1 and 2, and as it passes on through warmer and at last glowing ware, it will result that the kiln fires are supplied with atmospheric air almost as hot as the furnace itself. In chamber No. 7 the fire is burning, and when its contents have reached the desired temperature, No. 8 will have arrived at such a degree from the absorption of the waste heat, that the fuel introduced from the top is instantly inflamed.

The compartments Nos. 9, 10, 11, and 12, will be dried off, and heated one after another by the waste heat which passes through and expends itself on the contents of these chambers, and on its arrival in No. 12, meeting with the obstruction of the large damper, it is conducted by the small flue to the chimney, with its temperature again so lowered that it will only just support the draught. No. 1 being now filled again, the damper between 12 and 1 is lifted and lowered between 1 and 2. The bell damper above the mouth of the flue No. 12 is lowered, and that of No. 1 lifted. The doorway of No. 12 is then closed, and that of the compartment No. 3 opened, the contents of which will be sufficiently cooled to be taken out, while No. 2, which is empty, can be filled again.

On the 5th of January, 1864, Professor J. Thomson, of Belfast, read a paper on the manufacture of bricks, before the Chemico-Agricultural Society of Ulster, in which he referred at considerable length to the Hoffmann oven. The following is an abstract of his paper:— Having explained the chief methods in use for working the clay and forming it into bricks ready for the kiln, he then turned attention to the great loss of heat which occurs in the ordinary modes of burning bricks in common kilns. This loss is twofold. First, during the burning of the bricks the air which has passed through the fuel, or among the heated bricks, and the smoke, including the gaseous products generally, passes away from the kiln to waste at a very high temperature, even at a red heat, during a considerable part of the process. Secondly, when the bricks are raised to the high temperature required to burn them, and render them permanently hard, the great store of heat which they contain is entirely thrown to waste while they are left to cool.' In this new kiln a remarkable economy of fuel is effected, by saving the twofold loss of heat already mentioned: first, it saves the heat of the gaseous products of combustion and unconsumed air passing through and away from the burning bricks, by applying this heat effectively in drying the new fresh bricks about to be burnt, and raising them up to an incandescent temperature, so that only a very slight addition of heat from ignited fuel directly is required to complete their burning; and, secondly, it saves the heat of the cooling bricks, after their having been sufficiently fired, by applying it all again in warming the air which goes forward to supply the fires; so that the fuel is burnt with air already at nearly an incandescent temperature, instead of requiring, as usual, to heat the air for its own combustion. Professor Thomson explained, as an example, the large kiln which Mr. Moore was then constructing at his brick-works at Hayfield Park, in the neighbourhood of Belfast. The kiln, as will be seen, is built in the form of a large arched passage, like a railway tunnel, bending round in going forward on the ground till it closes with itself to form a great circular ring-chamber, within which the burning of the bricks is carried on. This ring-chamber may be of any convenient dimensions, 160 ft. diameter being a suitable size. Round its circumference there are twenty-four entrance doorways, admitting of being closed with temporarily-built bricks and clay, so as to retain the heat and exclude all entrance of air by the doorways so built up. The great ring-chamber may now be conceived as consisting of twenty-four compartments or spaces, with one of these doorways to each. In the centre of the ring a high chimney is erected, and from each of the twenty-four compartments of the annular chamber an underground flue leads into the chimney. There are, then, twenty-four of these flues converging towards the centre like the spokes of a wheel, and each flue has a valve, by which its communication with the chimney can be cut off. Arrangements are made by which a partition like a damper can be let down at pleasure, or otherwise placed, so as to cut off all communication between any of the twenty-four compartments of the ring-kiln and the next one. Let us now suppose the working of the kiln to have been already fairly established; for, after being once kindled, the fire is never extinguished, but the burning of new bricks and the removal of the finished produce are carried on by a continuous and regular process from day to day. Two adjacent compartments have this day their entrance doors open, all the rest being perfectly closed. By the arrangement of the valves in the flues, and the large partition, the air which gets admittance alone by the two open doors has to go round the whole circuit of the ring-kiln in order to be drawn into the chimney. From one of the two open compartments men are taking out the finished and cooled bricks, and in the other one they are building up newly-formed unburnt bricks which are not yet quite dry. The air, entering by these two compartments, passes first among bricks almost cold and takes up their heat, and then goes forward to warmer bricks, and then to hotter and hotter, always carrying the heat of the cooling bricks forward with it till it reaches the part of the ring diametrically opposite to the two open and cold compartments. At this place it gets a final accession of heat from the burning of a very small quantity of small coal, which is dropped in among the bricks from time to time by numerous small openings furnished with air-tight movable lids. Thus at this part of the kiln there is generated the full intensity of heat which is required for the burning of the bricks. The hot air, including the products of combustion, which, for brevity, we may call the smoke, though it is really perfectly gaseous and free from sooty particles, then passes forward to the bricks, which, by its continuous current, are being heated; and it passes on among them from hot bricks to those which are less and less hot, heating them as it goes, and then passes on to those which are still damp, drying them as it goes; and then it passes to the chimney, in a state almost cold, and saturated with the moisture, in the form of steam or vapour, which it has taken from the damp bricks. On the following day to that on which the operations just described have been going on, the partition is shifted forwards by the space of one compartment, and a corresponding change is made as to the flue which is to communicate with the chimney, and as to the pair of compartments open for the admission of air and for the removal of finished cold bricks, and the building in of fresh damp bricks; and so the air, including the products of combustion, at the end of its circuit in the annular chamber, just before passing off to the chimney, now passes among the fresh bricks which were described as built in on the yesterday of this new day. The place where the small-coal fuel is thrown in is also advanced round the circle by the stage of one compartment; and so now the whole process goes on just as it did yesterday. The fire thus makes a complete circuit of the annular chamber in twenty-four working days. The whole process may be left dormant on Sundays, merely by the closing of all apertures for the admission of the current of air. The same kind of kiln, with the same process of working, is applicable in the burning of lime; and both for the brick-burning and the lime-burning, the saving of fuel, relatively to what is consumed by the ordinary methods, is such as to appear at first sight almost incredible.

The Hoffmann or Chamberlain kiln is not so easily applicable to burning lime as it is to brick, nor will it answer without considerable modification for burning thin and light tiles or pottery. There must be *mass* enough in the goods to be fired to afford the requisite magazine of absorbed heat to be afterwards used up, and the draught must not be impeded as by the breaking down of limestone when burnt into lime.

Those kilns are not necessarily made circular. They are, indeed, now more usually rectangular, with or without rounded ends, in plan. When originally writing the preceding, the author of this chapter had not himself seen those kilns at work, and hence quoted from others as to their properties, &c. He has since, however, had occasion, professionally, to make himself fully acquainted with their construction and performance, and can indorse fully all that has been stated, and, indeed, might say much more in their commendation.

Many structural improvements and simplifications have latterly been made in those kilns; but as the patentee, Mr. H. Chamberlain, as a Pottery Engineer, is professionally engaged in providing designs for those who employ these kilns, it would not be fair that the writer should here enter into further details.

APPENDIX I.

The following paper was read by Mr. Tomlinson at a meeting of the Geologists' Association, on February 3, 1862:—

On the Plasticity and Odour of Clay.

It is a happy result of Bacon's method of inquiry that science is not required to explain the causes of things, but to state the laws of phenomena. Nevertheless, while these laws are obscure, and facts are scattered, theory may often do good service by collecting and marshalling them: for, as our great master of induction well observes, "Facts are the soldiers, but theory is the general." And again, "Truth is more easily evolved from error than from confusion." That is, a bad theory is better than none at all, for it serves to collect and arrange the facts, and thus makes them more easy to handle.

In these remarks must be found my excuse to-night for endeavouring to bind together some of the facts respecting a property of a very common substance; namely, the Plasticity of Clay.

The more I consider this property the more wonderful and inexplicable does it appear. Take a mass of dry clay; it cracks easily, and crumbles readily: add to it a certain proportion of water, and it becomes *plastic*—it obeys the will of the artist or the artizan, who can, out of this yielding mass, *create* new forms, or perpetuate old ones. Drive off the water at a red heat, and plasticity is for ever lost; *rigidity* takes its place: the clay is no longer clay, but something else. It may be reduced to powder, and ground up with water; but no art or science can again confer upon it its plasticity.

All this is very wonderful. There is another fact that is equally so: if we combine the constituents of clay in the proportions indicated by the analysis of some pure type of that substance, we fail to produce plasticity. I have on the table specimens of Dorset clays dry and crumbling; the same wet and plastic; and the same in the forms of casts of fossils, which have been passed through the fire, and have exchanged plasticity for rigidity. They are, in fact, in the form of *biscuit.*

With respect to the temperature at which clay becomes rigid, we have no accurate information. It is much lower than is generally supposed, as will appear from the following experiment:—I pounded and sifted some dry Dorset clay, and exposed it to a sand-bath heat in three portions varying from about 300° to 600°. Specimens were taken out from time to time, and rubbed up with water, but they did not lose their plasticity. Some clay was put into a test tube with a small quantity of mercury, and heated until the mercury began to boil. At this temperature (viz. 650°) the clay did not cease to be plastic. The flame of a spirit-lamp was applied, and the tube was heated below redness; after which the clay, on being mixed with water, showed no sign of plasticity.

In experiments of this kind, the first action of the heat is to drive off the hygrometric water. The clay then becomes dry, but is not chemically changed; it does not cease to be plastic. On continuing to raise the temperature, the chemically combined water is separated, and the clay undergoes a molecular change, which prevents it from taking up water again, except mechanically. With the loss of this chemically combined water, clay ceases to be plastic.

It was, I believe, first noticed by Brongniart,* that we cannot produce plasticity by the synthesis of clay. The fire clay of Stourbridge, for example, is a hydrated silicate of alumina, represented by the formula $Al_2\,O_3$, $2\,Si\,O_2 + 2\,Aq$. If we mix one atom of the sesquioxide of alumina with 2 atoms of silica and 2 of water, we get a compound which cannot be called clay, since it is wanting in plasticity.

It is quite easy to obtain either alumina or silica in the gelatinous state; but we cannot obtain them in the plastic state.

Clay is almost the only substance in the mineral kingdom that possesses plasticity. In loam, if the sand be in large proportion, and in marl, if calcareous matters abound, so as to deprive either material of plasticity, it ceases to be clay. There are also certain silicates of alumina which are not plastic; such as bole, lithomarge, and fullers'-earth. Bole consists chiefly of a hydrated bisilicate of alumina, in which a portion of the alumina is replaced by sesquioxide of iron. Lithomarge also contains iron, and is sometimes so compact as to be used for slate-pencils. Fullers'-earth contains lime, magnesia, and iron, in addition to its principal ingredients.

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* "Traité des Arts Céramiques." Paris, 1844. Vol. I. p. 82.

There is probably no substance so indeterminate in its composition as clay. Regarding it, as Lyell does,[*] as "nothing more than mud derived from the decomposition of wearing down of rocks," it must necessarily contain a variety of substances; such as oxide of iron, lime, magnesia, potash, silica, bitumen, fragments of undecomposed rock, &c. These substances impair the plasticity of the clay, and impress upon it certain characters which are of more importance to the manufacturer than to the chemist, or the geologist. Brongniart[†] enumerates, and gives the analyses of no fewer than 167 clays and 28 kaolins, all of which are in use in the arts in different parts of the world. They probably all differ in plasticity, but they all possess it; and at a high temperature exchange it for rigidity. A rough method of measuring the plasticity of different clays is to note the length to which a cylinder of each can be drawn out in a vertical direction without breaking. In such a comparison, the clays must, of course, be worked equally fine, and contain the same proportion of water.

It is commonly stated that the ingredient that confers plasticity on clay is its alumina; and yet, strange to say, pure alumina alone whether gelatinous, or after having been dried and ground up with water for a long time, never gives a plastic paste. Indeed, nothing can be conceived less plastic than gelatinous alumina, as may be seen from the specimens on the table. We may drive off most of the water from this gelatinous hydrate, but it will not become plastic. Or we may form clay by mingling solutions of the silicate of alumina and the aluminate of potash. You see they are perfectly fluid. I apply the heat of a spirit-lamp, and we get an opalescent gelatinous mass, but still no plasticity. We have, indeed, formed a gelatinous clay.

We cannot say that the gelatinous state of alumina is the cause of plasticity in clay; for silica may be made as gelatinous as alumina, and silica is certainly not the cause of plasticity. It may be that the strong affinity of alumina for water (retaining a portion of it even when near a red heat) may be the cause of this property—just as turpentine renders wax plastic; and water and gluten confer the same property on starch.

We have seen that clay ceases to be plastic when its chemically combined water has been driven off. Still, however, water cannot be said to be the cause of plasticity, as a general property, since we have, in melted glass, a more perfect example of plasticity even than

[*] "Manual of Elementary Geology" (1855), p. 11.

[†] "Des Arts Céramiques," Atlas of Plates.

in clay; and few substances are more plastic than sealing-wax at a certain temperature.

A clear idea of plasticity, and of some of the other mechanical properties of matter, may probably be gained by considering them as variations of the forces of cohesion and adhesion, and by bringing these, in their turn, under Newton's great law of attraction, which, whether exerted between atoms or masses, is directly as the mass, and inversely as the squares of the distances.

Now, if we suppose the distances between the molecules of matter to be 1-millionth or billionth, or 2, 3, 4, 5, 6, &c., millionths or billionths of an inch asunder, the intensity of their attractions will be 1, $\frac{1}{4}$th, $\frac{1}{9}$th, $\frac{1}{16}$th, &c., or, to represent it in a tabular form:—

Distances	1	2	3	4	5	6	7	8	9	10, &c.
Intensities of attraction	1	$\frac{1}{4}$	$\frac{1}{9}$	$\frac{1}{16}$	$\frac{1}{25}$	$\frac{1}{36}$	$\frac{1}{49}$	$\frac{1}{64}$	$\frac{1}{81}$	$\frac{1}{100}$, &c.

Suppose the molecules to be of the same density, but at different distances apart, as represented in the upper line. At the distance of 1-millionth of an inch we get an intensity of attraction represented by 1. At 2-millionths of an inch the force of attraction is only one-fourth. Now, the idea is this, that the mechanical properties of matter,—such as porosity, tenacity, hardness, brittleness, plasticity, elasticity, &c., depend upon variations in the attractive force of the molecules according to the distances apart of such molecules. Thus, if the molecules of clay require to be 5-millionths of an inch apart in order to produce plasticity, the intensity of attraction between them will be represented by $\frac{1}{25}$th; but if such clay be passed through the fire, and the molecules, in consequence of the escape of water, be brought nearer together, and rigidly fixed at 4-millionths of an inch asunder, the force of attraction will then be $\frac{1}{16}$th.

Now, the method of arranging the particles of clay at that precise distance that shall impart plasticity, is one of Nature's secrets that we have not yet succeeded in penetrating. It may be that the circumstances under which clay is formed and deposited, or the time that has elapsed since its formation, or the pressure of the superposed layers, may have so arranged the particles as to enable them to become plastic when the proper proportion of water is added. It may be that a certain state of disintegration is required on the part of the alumina and the silica, so that their proximate elements shall be neither too fine nor too coarse; or it may be that the silica, in combining with the alumina, separates the atoms of the latter to precisely those distances required for the development of the property;

or, lastly, the presence of a small portion of animal or other organic matter in clay may have something to do with this remarkable property.

An extensive series of experiments, by Delesse,* show the presence of animal matter in quartz and various rocks, where its presence had not previously been suspected; and this may have as important an effect in modifying the properties of a mineral as the presence of minute portions of bodies, formerly entered as impurities, has in producing pseudo morphous crystals.

Still, the question recurs, Why is not a clay artificially formed from pure materials plastic? The answer is, that we do not know all the conditions of plasticity. We *do* know the conditions under which some mechanical properties exist—such as the hardness of steel, the brittleness of unannealed glass—and can confer or remove such properties at pleasure. But with respect to plasticity, we can only confer a factitious property of this kind on mineral substances by taking advantage of another property which it somewhat resembles, namely, *viscosity* or *viscidity*. Viscosity differs in plasticity in this, that the viscous body does not retain the form impressed upon it when the force is removed, as a plastic body does. The materials of the old soft porcelain of Sèvres had no plasticity; but this property was conferred by means of soft soap and parchment size.†

Without speculating further on the nature of plasticity, I may remark that in the ancient philosophy the word was one of power. Derived from the Greek πλασσειν, or πλαττειν, "to form," or "to create," it not only included the arts of modelling in clay, but also sculpture and painting, and, by a refinement of language, poetry and music. Plato and Aristotle even supposed that a plastic virtue resided in the earth, or did so originally, by virtue of which it put forth plants, &c.; and that animals and men were but effects of this plastic power. They did not suppose the world to have been made with labour and difficulty, as an architect builds a house; but that a certain "efficient nature" (*natura effectrix*) inherent and residing in matter itself, disposed and tempered it, and from it constructed the whole world. Aristotle distinctly recognises *mind* as the principal and directing cause, and *natura* as a subservient or executive instrument. Even in later times men have contended for the existence of a plastic nature, or incorporeal substance endowed with a vegetative life; but not with sensation or thought, penetrating the whole universe, and producing those phenomena of matter which could not be solved by mechanical laws. The learned Cudworth supports this view,* and the discussions into which it led him and other metaphysicians form a curious chapter in the history of the human mind. In England we do not now retain the term *plasticity*, except as a physical property of matter;† but in Germany it has still an extensive figurative meaning. The word *plastisch* still means *bildend* or *schöpferisch* (i.e. "creative"); and it is still applied not only to sculpture, but also to painting, poetry, and music. A German well understands the expression "plastische Gedanken," or "plastic thoughts."

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* "De l'azote et des matières organiques dans l'ecorce terrestre."—*Annales des Mines*, xviii., 1860.

† Brongniart ("Des Arts Céramiques") says that the old *porcelaines tendres* were formed of 22 per cent. of fused nitre, 60 of Fontainebleau sand, 7·2 of salt, 3·6 of alum, 3·6 of soda, and 3·6 of gypsum. These materials were fritted and ground, and 75 parts taken, to which were added white chalk 17 parts, marl 8. This mixture was ground, sifted very fine, and made up into a paste with 1-8th soft soap and size, or, at a later period, with gum tragacanth.

Before concluding, I would refer to another property of clay, which seems to me as wonderful as its plasticity; namely, its *odour* when breathed on, or when a shower of rain first begins to wet a dry clayey soil. This odour is commonly referred to alumina, and yet, strange to say, pure alumina gives off no odour when breathed on or wetted. The fact is, the peculiar odour referred to belongs only to impure clays, and chiefly to those that contain oxide of iron. This was pointed out by Brongniart as far back as 1816,‡ who also remarked that minerals which do not contain alumina, such as pulverised chalcedony, possess this remarkable property.

I have found that a pure kaolin, ground up in a mortar with a small quantity of water, emits a slight odour, which, however, becomes much more sensible if a little sesquioxide of iron be added.

Smooth quartz pebbles when rubbed together give an electric spark, and a fetid odour. It is commonly supposed that sea-side pebbles alone possess this property; but the odour belongs equally to those found among gravel overlying the chalk, and in ploughed lands where the surface is exposed to all the vicissitudes of the weather. It is quite possible that the odour of these pebbles may hereafter be traced to the presence of organic matter; but I cannot resist the reproduction here of a suggestive hint given me by my friend Professor Bloxam, who is reminded by the spark and odour from these pebbles of the presence of ozone.

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* See "The True Intellectual System of the Universe," by Ralph Cudworth, D.D., 1678. A reprint has been published by Tegg, in which see Vol. I., p. 226, *et seq.*

† Dr. Johnson defines *plastic* as "having the power to give form."

‡ "Dictionnaire des Sciences Naturelles," art. *Argile.*

What, again, is the cause of the odour in the narrow parts of stone buildings, not of new buildings alone, but of old ones, as in the staircases of old cathedrals?

I do not attempt to reply to these questions. It requires some amount of knowledge and experience to put them—but how much more to answer them!

ON DRYING BRICKS.

(*Extracted from Noble's "Professional Practice of Architects," p.* 143.)

"The observations by Richard Neve, above a century since, upon *stock bricks*, will illustrate the subject: 'When the *hack* is as high as they think fit, they *cover them with straw* till they are dry enough to burn,' &c., &c. He proceeds: 'A brickmaker being sent to Rumford, in Essex, went to work unadvisedly, and laid them *abroad* in a place to dry; but the sun, about ten o'clock, began to shine very hot, and the whole quantity of bricks *burst to pieces*, so that he was forced to go to work again: and then, before the sun shone too hot, he thatched or covered them over with straw till the next morning, when removing it, they did very well when set on the hack; and when burnt, were curious *red bricks*, which would ring when hit with any hard thing.'"

ON THE USE OF COAL DUST IN MAKING CLAMP BRICKS.

(*Extracted from Noble's " Professional Practice of Architects," p.* 153.)

"Natives should be employed (*in making bricks in Wales*) in the manufacture, in preference to London hands, as the former use *coal* dust in preparing the earth, and not breeze (ashes), as about London; and provided an undue portion of coal is used, a whole *clamp* would be destroyed, of which there was an instance at Lampeter (Cardiganshire). An Islington brickmaker was sent to Wales, and as he was too conceited to make inquiries, or to receive information, set light to a *clamp* he had prepared with coal, being 70,700; and in a very short time the whole kiln was in one general blaze. The man being alarmed, took to his heels, and, unlike Lot's wife, he turned not back, neither looked behind him. Even from the heights leading to Landovery the *reflection* was quite enough for him; nor did he stop till he reached London, being, as he said, '*afeared*' they would catch him and put him in prison!"

BRICKMAKING AT GREAT GRIMSBY, LINCOLNSHIRE.

Large quantities of bricks have been made during the last few years at Great Grimsby, for the Dock Company, from the Humber silt. These bricks are remarkable for their colour, which varies in the same brick from dark purple to dirty white, passing through various shades of blue, red, and yellow, in the space of two or three inches. The silt, when first dug out of the bed of the Humber, is of a dark blue colour, which soon, from exposure to the air, changes to a brown.

The bricks made for the Dock Company were burnt in close clamps—fired with layers of small coal, but without coal-dust or ashes being mixed with the clay as in London brickmaking. With the first clamps there was much waste, the quantity of fuel being excessive, and the bricks were cracked and made brittle in consequence; but the experience obtained by the first trials has led to the production of a sound well-burnt brick, with, however, the peculiar colour above mentioned.

Considerable quantities of bricks have been lately made for sale at Great Grimsby, and burnt in clamps with flues, as in kiln burning, which method appears to be attended with less waste than close clamping.

The *slack* or small coal used for fuel may cost from 2*s.* 6*d.* to 4*s.* per 1,000 bricks. The cost of clay getting, tempering, moulding, and drying, is about 8*s.* 6*d.* per 1,000. The moulds used are of wood, plated with iron. The process employed is that known as slop-moulding.

Kilns as well as clamps are used in this part of Lincolnshire; their construction being similar to that of the kilns in general use in the Midland Counties.

BRICKMAKING IN SUFFOLK.

Two kinds of bricks are made in Suffolk, viz., reds and whites. The latter are much esteemed for their shape and colour, and large quantities are annually sent to London, for facing buildings of a superior class.

Clay.—The supplies of brick-earth are chiefly derived from the plastic clays lying above the chalk, although the blue clay is occasionally used.

The clays in most parts are too strong to be used as they rise, and have consequently to be mixed with a white loam or a milder earth.

Tempering.—The clay is turned over in February and March, and in some parts of Suffolk it is passed through the wash-mill, but this is not generally the case.

Tempering is generally performed by spade labour, but the pug-mill is sometimes used, although not commonly, for white bricks; it is, however, used for all other white ware.

Moulding.—*The brick mould* is of wood, shod with iron; the dimensions vary slightly according to the nature of the clay, but are usually as follows: $9\frac{7}{8}$ths long by $4\frac{15}{16}$ths wide and $3\frac{1}{4}$ deep. There is no hollow formed in the bottom of the brick for the mortar joint. Brass moulds are unknown.

Sea sand is used in the process of moulding, for sanding the mould and the table.

The strike is used for taking off the superfluous clay from the mould. The use of the plane is not known.

Drying.—The bricks are not dried on flats as in the Midland Counties, but are taken directly from the moulding stool to the hacks. Sheds are used in some yards, and drying houses with flued floors are used in winter for pantiles and kiln tiles, but not for bricks.

The length of a hack is about 70 yards, and each moulder will keep four hacks going.

The *time* required for drying in the hacks of course varies according to the weather, but may be stated on an average at about eighteen days for red bricks. White bricks dry somewhat quicker.

The *contraction* of the clay in drying amounts to about $\frac{7}{8}$ in. in the length of a brick, and, if properly burnt, the shrinkage in the kiln is imperceptible.

The *weight* of a brick, when first moulded, is about 8 lbs.; when dried, about 7 lbs.; and when burnt, about 6 lbs.; but much depends upon the nature of the earth.

Burning.—*The construction of the kiln* is quite different from that of the kilns used in other parts of England, having two arched furnaces running its whole length underneath the floor, which is formed of a kind of lattice work, through the openings of which the heat ascends from the furnaces below.

The cost of erecting a kiln to burn 50,000 whites is about £145. A kiln to burn 35,000 reds costs about £100.

The bricks are commonly set in the kiln in bolts two bricks long by ten on; but some brickmakers prefer to cross them in the alternate courses, in order to admit the heat more freely.

The *fuel* used is coal, and the quantity consumed is about half a ton per 1,000 for white, and 7 cwt. per 1,000 for red, bricks.

The *time of burning* is about 60 hours for white, and 40 hours for red, bricks; white bricks requiring a greater heat than the red ones to bring them to their proper colour.

Cost of Manufacture.

The selling prices vary from £1 8*s.* to £2 per 1,000 for reds, and from £2 to £2 10*s.* per 1,000 for whites.

Of red bricks two qualities only are distinguished, viz., outside and inside; of white, four qualities are distinguished, viz., best, 2nd, 3rd, and murrays.

The price of the ordinary red brick is about £1 8*s.* per 1,000, and the cost may be thus divided:—

	£	*s.*	*d.*
Clay digging, per 1,000	0	2	0
Tempering, ditto	0	1	0
Moulding, ditto	0	4	6
Drying, ditto	0	0	6
Moulding sand, ditto	0	0	9
Barrowing from hacks and setting kiln, ditto	0	1	6
Burning, ditto	0	1	6
Drawing kiln, ditto	0	0	6
Stacking, ditto	0	0	3
Cost of labour per 1,000	£0	12	6
Coals, about	0	7	0
Rent, tools, contingencies, and profit	0	8	6
Selling price at the yard, about	**£1**	**8**	**0**

White bricks are made in many parts of England, but the Suffolk whites have the pre-eminence over all others.

The white bricks made near Lincoln are remarkable for *swelling* when laid in work, which causes them to throw off the mortar joints, and renders it impossible to make use of them in good work.

The clay from which these bricks are made extends from the Witham northwards as far as the Humber, and, so far as we are aware, possesses the same property throughout this distance, the bricks made from it at various points between the Witham and the Humber having the common defect of swelling after burning. A curious specimen of this may be seen in a large chimney at Saxilby, which has a complete twist, from the irregular swelling of the brickwork.

The peculiar property of swelling after burning is not confined to the Lincolnshire white clay. The author was informed some years ago, by Mr. Vignoles, C.E., that some of the bricks made on the Midland Counties Line of Railway, between Rugby and Derby, had the same defect.

For the above particulars respecting the Lincolnshire white bricks we are indebted to Mr. William Kirk, of Sleaford.

ON THE MAKING AND BURNING OF DRAIN TILES.

Extracts from a communication by Mr. Law Hodges, published in the Journal of the Royal Agricultural Society of England, Vol. V. Part II. :—

"Reflecting on these obstacles to universal drainage, where required, I conferred with Mr. John Hatcher (brick and tile maker, and potter, Benenden, Kent), on the possibility of erecting a kiln of common clay that would be effectual for burning these tiles, and of cheap construction—and the result was the building one in my brickyard in July last, and the constant use of it until the wet weather at the commencement of this winter compelled its discontinuance, but not until it had burnt nearly 80,000 excellent tiles; and in the ensuing spring it will be again in regular use.

"I shall now proceed to take in order the six points enumerated under the 9th head of the Prize Essays for 1845, as printed in the last volume of the Royal Agricultural Society's Journal, viz. :—

"1st. Mode of working clay according to its quality.

"2nd. Machine for making tiles.

"3rd. Sheds for drying tiles.

"4th. Construction of kilns.

"5th. Cost of forming the establishment.

"6th. Cost of tiles when ready for sale.

"1st Point. Working the clay.

"All clay intended for working next season must be dug in the winter, and the earlier the better, so as to expose it as much as possible to frost and snow. Care must be taken, if there are small stones in it, to dig it in small pits, and cast out the stones as much as possible, and also to well mix the top and bottom of the bed of clay together. It is almost impossible to give minute directions as to mixing clay with loam, or with marl when necessary, for the better working it afterwards, as the difference of the clays in purity and tenacity is such as to require distinct management in this respect in various localities; but all the clay dug for tile-making will require to be wheeled to the place where the pug-mill is to work it; it must be there well turned and mixed in the spring, and properly wetted, and finally spatted down and smoothed by the spade, and the whole heap well covered with litter to keep it moist and fit for use through the ensuing season of tile-making.

"2nd Point. Machine for making tiles.

"For the reasons already alluded to, I prefer Hatcher's machine. Its simplicity of construction, and the small amount of hand labour required to work it, would alone recommend it; for one man and three boys will turn out nearly 11,000 pipe tiles of 1 in. bore in a day of ten hours, and so in proportion for pipes of a larger diameter; but it has the great advantage of being movable, and those who work it draw it along the shed in which the tiles are deposited for drying, previously to their being burnt: thus each tile is handled only once, for it is taken off the machine by the little boys who stand on each side, and at once placed in the rows on either side of the drying shed, thus rendering the use of shelves in the sheds wholly unnecessary, for the tiles soon acquire a solidity to bear row upon row of tiles, till they reach the roof of the sheds on either side; and they dry without warping or losing their shape in any way.

"The price of this machine is £25, and it may be proper to add, that the machine makes the very best roofing tiles that can be made, and at less than half the price of those made by hand, as well as being much lighter, and closer, and straighter, in consequence of the pressure through the die.

"It is necessary, in order to ensure the due mixing of the clay, as well as to form it into the exact shape to fill the cylinders of the machine, to have a pug-mill. Messrs. Cottam and Hallen make these also, and charge £10 for them. This mill must be worked by a horse; in general one day's work at the mill will furnish rather more prepared clay than the machine will turn into tiles in two days

"3rd Point. Sheds for drying.

"The sheds necessary for this system of tile-making will be of a temporary kind: strong hurdles pitched firmly in the ground in two parallel straight lines, 7 ft. apart, will form the sides of the sheds, and the roof will be formed also of hurdles placed endways and tied together at the top, as well as to the upper slit of the hurdle, with strong tarred twine, forming the ridge of the roof exactly over the middle of the shed. They must then be lightly thatched with straw or heath, and the sharpness of this roof will effectually protect the tiles from rain. Two of these sheds, each 110 ft. long, will keep one of the kilns hereafter described in full work.

"N.B.—These sheds should be so built as to have one end close to the pug-mill and the clay-heap, only leaving just room for the horse to work the mill, and the other end near the kiln. Attention to this matter saves future labour, and therefore money.

"4th Point. Construction of kilns.

"The form of the clay kiln is circular, 11 ft. in diameter, and 7 ft. high. It is wholly built of damp earth, rammed firmly together, and plastered inside and out with loam. The earth to form the walls is dug out round the base, leaving a circular trench about 4 ft. wide and as many deep, into which the fire-holes of the kiln open. If wood be the fuel used, three fire-holes are sufficient; if coal, four will be needed. About 1,200 common bricks are wanted to build these fire-holes and flues; if coal is used, rather fewer bricks will be wanted, but then some iron bars are necessary—six bars to each fire-hole.

"The earthen walls are 4 ft. thick at the floor of the kiln, are 7 ft. high, and tapering to the thickness of 2 ft. at the top; this will determine the slope of the exterior face of the kiln. The inside of the wall is carried np perpendicularly, and the loam plastering inside becomes, after the first burning, like a brick wall. The kiln may be safely erected in March, or whenever the danger of injury

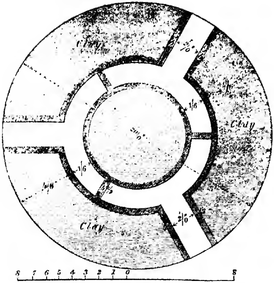


Fig. 1. *Plan of Kiln at* A B, *fig.* 3.

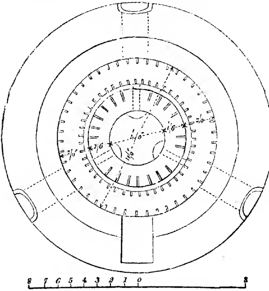
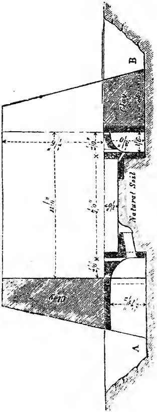


Fig. 2. *Plan of Top of Kiln.*

Fig. 3.



Section of Kiln.

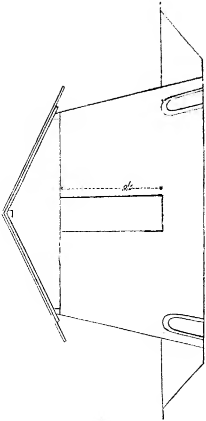
from frost is over. After the summer use of it, it must be protected by faggots or litter against the wet and the frost of winter.

"A kiln of these dimensions will contain—

47,000 1-in. bore pipe tiles.
32,500 1¼ ,, ,,
20,000 1¾ ,, ,,
12,000 2¼ ,, ,,

and the last-mentioned size will hold the same number of the inch pipes inside of them, making therefore 24,000 of both sizes. In good

Fig. 4.



Elevation.

weather this kiln can be filled, burnt, and discharged once every fortnight; and fifteen kilns may be obtained in a good season, producing—

705,000 1-in. pipe tiles.
Or 487,500 1¼ " "
Or 300,000 1¾ " "

and so on in proportion for other sizes.

"N.B.—If a kiln of larger diameter be built, there must be more fire-holes, and additional shed room.

TABLE 3.

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Si O	44·00	66·68	53·66	46·38	49·44	58·07	32·80	28·50	58·97	33·06
Al_2O_3	36·06	26·08	32·00	38·04	34·26	27·38	10·40		9·97	11·20*
Ca O	4·08	0·84	0·40	1·20	1·48	0·50	..	..	0·02	..
$CaO + CO_2$	..	..	..	..	..	..	38·40	46·50	20·16	39·80
Mg O	2·00	trace	trace	trace	1·94	trace	..	..	0·04	..
$MgO + CO_2$	..	..	..	..	..	..	2·20	3·50	4·21	6·01
Fe_2O_3	..	1·26	..	..	..	..	..	..	4·25	..
Fe O	2·00	..	0·27	1·04	7·74	3·30	5·20	3·00	..	..
Silica, or Sand	..	..	..	..	..	..	..	14·50	..	..
Alkalies NO + KO and Water	..	5·11	12·08	13·57	5·14	10·30	19·60	4·00	3·32	10·00

* With Fe_2O_3.

Most of these clays, as found in nature, contain some organic matters and pebbles of foreign bodies. Unless these are of hard pyrites or limestone, they are unimportant. Flinty pebbles can generally be crushed in the clay-mill, or taken out by the screen or sieve.

Clays should, if possible, be delivered into the brick-yard in their moist natural state; for when they have been permitted to dry up under a scorching sun or drying wind, they shrink and harden greatly, and the labour of mixing into good brick "stuff" is greater, and the plastic mixture not as free and nice as before.

Whether a natural clay contains much or little *sand* naturally is not important. Every clay requires more or less grinding and mixing; and when sand in a separate form is at hand, it is easiest and best mixed in such proportions as we may require in the pug-mill. Clays naturally very rich in lime or in the alkalies (derived from felspar) are the worst, and in fact a clay that contains more than about 5 per cent. of lime, at the utmost, is scarcely fitted for good brickmaking.

If the lime be in the state of carbonate. it is so much the worse; and if it exist in the state of diffused limestone or chalk-*pebbles*, it is worst of all; for these burn into caustic lime in the brick-kiln, and then as in after-time the brick absorbs moisture and carbonic acid, the contained nodules of lime "slack," and swell in their places, and so burst the brick to pieces. This is one of the most prevalent evils of the ill-made bricks which are almost universal in Ireland, arising from the wide diffusion of limestone gravel in that country, and the total neglect of grinding or efficient sifting of the clay.

Iron pyrites also is a not uncommon accidental product present in clays, and unless separated, durable, to say nothing of well-coloured, brick can never be made of the clay. The pyrites in the kiln is but partially decomposed: oxide of iron and basic sulphides of iron remain. When at an after-period these are exposed to air and moisture, which are absorbed to all depths in brick, oxidation takes place, sulphate of iron, and frequently also sulphates of lime or alums (sulphates with double bases), are formed, and, crystallising within the mass of the brick, split it to pieces.

Common salt is nearly always present in minute quantity in clays; but when these are taken from the sea-shore, or without or beneath the sea-washes, or from localities in and about the salt-formations (trias), they frequently, though in all other respects excellent clays, are unfit for burning into good brick. Chloride of sodium is not only a powerful flux when mixed even in very small proportion in clays, but possesses the property of being volatilized by the heat of the brick-kiln, and in that condition it carries with it, in a volatile state, various metallic compounds, as those of iron, which exist in nearly all clays, and also act as fluxes. The result is that bricks made of such clays tend to fuse, to warp, twist, and agglutinate together upon the surfaces long before they have been exposed to a sufficient or sufficiently prolonged heat to burn them *to the core* into good *hard* brick. "Place bricks" can be made of such clay, but nothing more; and these are always bad, because never afterwards free from hygrometric moisture.

Much carbonaceous matter naturally mixed in clays is also in certain states objectionable, for when not burnt completely and in the kiln, which is sometimes with the denser clays difficult, the bricks are of a different colour in the interior and exterior, and will not bear cutting for face-work, without spoiling the appearance of the brick-work. But, worse than this, such bricks when wetted in the wall occasionally pass out soluble compounds like those absorbed from soot by the bricks of the flue, and, like those (when used again in new work), discolour plastering or stucco-work.

The normal constituents of brick clays, then, may be said to be oxides of the earthy metals, and of a few others, hydrated or not, with silicic acid, and with small amounts of the alkalies, potash and soda, also present, together with several other chemical elements occasionally, but uncertainly, present in minute proportions, with which we need not concern ourselves. Silicic acid, the *great* electro-negative element of clays when combined with the oxides of the earthy bases, singly or in combination, and exposed to high temperatures in certain proportions, forms glass or enamel (*i.e.*, opaque glasses). Alumina, though in a less degree, also plays the part of acid towards the earthy bases, though itself a base with respect to silicic acid. As regards the oxides of the earthy metals, alumina, lime, magnesia, &c., these, in accordance with the general law of chemistry, that bodies in the same range combine, oxides with oxides, &c., also combine at high temperatures. The most powerful bases, such as the alkalies or oxides of potassium and of sodium, and the oxides of iron, combine more readily with silicic acid than do the earthy oxides. These combinations usually take the form of glass at once, the chief characteristic of which is the *vitreous* fracture. When such glasses are formed with oxides of earthy bases also present, they may assume crystalline or porcellaneous textures when cooled.

Porcelain, earthenware, and hard brick (such as the Staffordshire or Flintshire blue bricks) consist in substance of such compound glasses, diffused throughout their substance uniformly, and binding together the finely-diffused particles of the excess of earthy oxides which are present, or binding together fragmentary bits of uniformly-diffused silicic acid (sand, ground flint, &c.). The degree of fusibility, or of partial fusibility (agglutination), of any hard-baked brick depends, then, not only upon the chemical nature of the constituents of the clay, but upon the proportions in which these are present.

The laws, so far as they have been ascertained, upon which depends the induration or agglutination by heat of silicic and earthy compounds, with or without other metallic oxides present, have been elicited from innumerable experiments made by ceramic chemists upon very varied compounds. The phenomena are complex, and in great part as yet in results only empirical. We must refer for these to the works of Kirwan ("Mineralogy"), who made very many experiments upon known combinations of earths when exposed to heat—which have not in England attracted the attention they deserved—of Achard, Brongniart, Berthier, Lampadius, and various systematic chemical writers. Silica, alumina, lime, magnesia, are all infusible, *per se*, at the highest temperature of the porcelain furnace or brick-kiln.

Silicic acid combined with any *one* earth is less fusible than when combined with two or more—a proof that not only the silicic acid combines with each earth, but that these in its presence combine with each other. Binary compounds of silicic acid and of earths, or of earths with earths, are most usually infusible except at still higher temperatures. Compounds of silicic acid with alumina are less fusible than with lime, and these less so than with the alkalies.

With oxides of iron, silicic acid forms fusible compounds in certain proportions. Magnesia, present in large proportions with either of the other earths, produces a very difficultly-fusible compound. Where the silicic acid constitutes the largest proportion of the mass, it is much more fusible, the bases being *two* others combined, with or without alkalies; but if the silicic be in great excess (as in Dinas fire-brick), or if one or other of the earthy bases be in great excess, more especially alumina or magnesia, the mass is infusible in the kiln.

All difficultly-fusible and pulverulent oxides, as when obtained by precipitation or by levigation, when exposed for some time to a high temperature, become hard in grain, *i.e.*, indurated more or less, and frequently compacted. This is true even of some pure earths, such as alumina and magnesia, and of nearly all the oxides of the common metals. Compound oxides, when so exposed to heat, become still more indurated and compact, though presenting no traces of agglutination* or of fusion. Thus alumina and sesquioxide of iron become compact. This induration, which is probably rather a change in the state of molecular aggregation than a chemical combination, but which may be both, is much concerned in the production of certain qualities of brick; for example, the fine, soft, scarlet cutting brick—that which was so much employed for fine facing-brick in the reign of William III., down to George II.—presents no sign of agglutination; its constituents have merely become partially indurated and compacted by the fire. The same is true of many of the light-coloured bricks now in use.

Two sets of forces, then, are, or may be, in play in the burning of brick—chemical, and physical or molecular—and must be held in view by the scientific brickmaker. To the latter belongs the *contraction* that takes place in the process of firing of all porcelain and brick. This is greatest with those which contain most alumina, and with any given specimen, is great not only in proportion to the elevation of the temperature to which it is exposed, but with the duration of the time of exposure. It is least in compounds in which the silicic acid predominates; and if these pass partially from the crystalline to the vitreous state of aggregation in the firing, the specific gravity is reduced, and the increase of volume *may* more than equal the contraction. This is said to be the case with Dinas fire-brick, which, when highly heated in furnaces built of it, is said to expand.

Were brick constituted of silicic acid and *pure* clays only, it would be perfectly white. Bricks, like porcelain, owe their colour to admixed metallic oxides—iron in various states of oxidation, from prot. oxide to sesquioxide, or true chemical combinations of those with each other, or with the earths themselves, and present in the most varied proportions, give the whole range of colouring to bricks, from the lightest tawny yellow, through full yellow, orange, and to the rich scarlet of red facing-brick, almost as bright as red-lead. Where the proportion of oxide of iron present is very large, and it combines with silicic acid to form silicates of iron in or on the brick, its colour may be dark purple or nearly black, as is the Staffordshire blue brick; and when a small quantity of oxide of manganese is present also, the colour is still darkened, and may become quite black.

For light-coloured bricks the clays must be almost free from iron, and the latter must not be peroxidised, if possible, in the burning.

For the production of fine red brick, on the contrary, the clays must be pure, silicic acid not present in excess, oxide of iron present in abundant proportion, and be fully peroxidised, but must not be fused into a silicate of peroxide of iron, which is fatal then both to the texture and colour.

With a given constitution of brick clay, the final colour of the burnt brick depends upon a large number of conditions in the process of firing, but mainly upon two—viz., what proportion of *air* be admitted to the combustion of the fuel in the kiln—*i.e.*, whether the brick be finally burnt with an oxidising or a deoxidising flame; and whether or not, or in what proportion, steam or water be present in the brick, or be brought in the state of vapour in contact with it, when at elevated temperatures.

Upon an exact knowledge of the effects producible by the play of these conditions (chiefly) upon the brick in burning rests the power of the brickmaker to vary or maintain with certainty the good colour of his ware, or to effect any desirable changes of colour of which his material may be susceptible.

From this very incomplete sketch it will be seen that brickmaking is one of the chemico-mechanical arts. Being so, we need scarcely say that the foundation of all accurate and predictive knowledge of it must be based upon a sound knowledge of chemistry, and of the laws of physics, and of heat especially, which is but a branch of the latter.

NOTES.

Coloured Bricks.

Quite a new branch of trade remains to be opened in the manufacture of coloured and intaglio bricks, so treated upon the one face-side only, for both external and internal decorative building.

What may be done in this way may be seen in the Romanesque domes of the interior covering of the great centre hall of the museum building of Trinity College, Dublin, erected, a few years since, by Messrs. Deane and Woodward, architects, in which ordinary bricks are enamelled in brilliant glazed colours, arranged in designs, upon the exposed face only.

The German architects are generally in advance of us in the art of ornamental polychrome brickwork, avoiding those hideous discords of colour that so offend the eye in many of our London buildings. See especially for this "Les Constructions en Briques, par Louis Degen, Ingénieur de la Commission Spéciale d'Architecture de la Ville de Munich," published in 1865, at Paris. It is marvellous how much beauty the German brick architects contrive to extract out of the judiciously-arranged patterns producible from mere common brick, combined with delicate and beautiful harmonies of tint and colour.

INFUSORIAL SILICEOUS MATERIALS, p. 22.

The bricks with which the arching of the floor of the Museum at Berlin was built, were made from this infusorial siliceous and microscopically porous material, mixed with a certain proportion of clay "slip." Many of the floor arches of the Pinnacotheca, however, were constructed of hollow bricks, in the form of frustra of cones, like flower-pots without bottoms, laid into place with plaster or cement.

Materials exist in Southern Italy in abundance, as also in many other places, from which brick of considerable strength and of great lightness might be readily and cheaply made, viz., either from certain varieties of volcanic tufa or from pumice-stone detritus. Of the former there are suitable beds close to Naples, and elsewhere; of the latter, inexhaustible supplies exist in the islands of Lipari, Ischia, and the Ponza Isles, from which it might be broght with facility.

PLASTICITY AND ODOUR OF CLAY, p. 210.

It is certainly not a general fact that no chemically pure precipitates are characterised by *plasticity*. Precipitated carbonate of lime and white-lead are instances to the contrary; but nearly all precipitates (especially when rapidly made), though to the eye amorphous, are in fact *crystalline*, as Stokes long ago proved microscopically (*Dublin Phil. Mag.*); and crystallised bodies are often not plastic.

WATER CHEMICALLY COMBINED OR MECHANICALLY PRESENT, p. 212.

Water mechanically present is one thing, but water chemically combined is another. Hydrate of alumina, in which the water plays the part of base, is a different body chemically from the alumina dehydrated and separated from its base by heat. The former may possess plasticity, the latter not, simply because the former has the power to retain, intimately diffused throughout its divided mass water in mechanical mixture, while the latter has not. This diffused water seems to be the real cause of the plasticity of clay and of all plastic precipitates; the minute, solid, and rigid particles slip over each other, as it were upon liquid rollers, just as two plates of glass or metal slip over each other when a film of water is interposed.

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